42D CONGRESS, 1st Session. } HOUSE OF REPRESENTATIVES. { Ex. Doc. No. 20.

ANNUAL REPORT

OF

THE BOARD OF REGENTS

OF THE

SMITHSONIAN INSTITUTION,

SHOWING

THE OPERATIONS, EXPENDITURES, AND CONDITION OF THE INSTITUTION FOR THE YEAR 1870.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1871.

CONGRESS OF THE UNITED STATES, IN THE HOUSE OF REPRESENTATIVES,
FORTY-SECOND CONGRESS, FIRST SESSION, *April* 19, 1871.

The following resolution, originating in the House of Representatives this day, has been concurred in by the Senate, viz:

"*Resolved, (the Senate concurring,)* That twelve thousand five hundred additional copies of the report of the Smithsonian Institution for the year 1870 be printed, twenty-five hundred of which shall be for the use of the Senate, five thousand for the use of the House, and five thousand for the use of the Institution: *Provided,* That the aggregate number of pages of said report shall not exceed four hundred and fifty, and that there shall be no illustrations except those furnished by the Institution."

Attest: EWD. McPHERSON,
Clerk.

LETTER

FROM THE

SECRETARY OF THE SMITHSONIAN INSTITUTION,

TRANSMITTING

The annual report of the Smithsonian Institution for the year 1870.

SMITHSONIAN INSTITUTION,
Washington, March 1, 1871.

SIR: In behalf of the Board of Regents, I have the honor to submit to the Congress of the United States the annual report of the operations, expenditures, and condition of the Smithsonian Institution for the year 1870.

I have the honor to be, very respectfully, your obedient servant,

JOSEPH HENRY,
Secretary Smithsonian Institution.

Hon. S. COLFAX,
President of the Senate.

Hon. J. G. BLAINE,
Speaker of the House of Representatives.

ANNUAL REPORT OF THE SMITHSONIAN INSTITUTION FOR 1870.

This document contains: 1. The programme of organization of the Smithsonian Institution. 2. The annual report of the Secretary, giving an account of the operations and condition of the establishment for the year 1870, with the statistics of collections, exchanges, meteorology, &c. 3. The report of the executive committee, exhibiting the financial affairs of the Institution, including a statement of the Smithson fund, the receipts and expenditures for the year 1870, and the estimates for 1871. 4. The proceedings of the Board of Regents. 5. A general appendix, consisting principally of reports of lectures, translations from foreign journals of articles not generally accessible, but of interest to meteorologists, correspondents of the Institution, teachers, and others interested in the promotion of knowledge.

THE SMITHSONIAN INSTITUTION.

ULYSSES S. GRANT.....President of the United States, *ex-officio* Presiding Officer of the Institution.
SALMON P. CHASE .....Chief Justice of the United States, Chancellor of the Institution, President of the Board of Regents.
JOSEPH HENRY ....Secretary (or Director) of the Institution.

REGENTS OF THE INSTITUTION.

S. P. CHASE...............Chief Justice of the United States, *President of the Board.*

S. COLFAX ....Vice-President of the United States.
HENRY D. COOKE ....Governor of the District of Columbia.
L. TRUMBULL ....Member of the Senate of the United States.
GARRETT DAVIS..........Member of the Senate of the United States.
H. HAMLIN................Member of the Senate of the United States.
J. A. GARFIELD..........Member of the House of Representatives.
L. P. POLAND............Member of the House of Representatives.
S. S. COX ....Member of the House of Representatives.
W. B. ASTOR..............Citizen of New York.
T. D. WOOLSEY..........Citizen of Connecticut.
L. AGASSIZ................Citizen of Massachusetts.

PETER PARKER ....Citizen of Washington.
JOHN MACLEAN ....Citizen of New Jersey. } EXECUTIVE COMMITTEE.
WILLIAM T. SHERMAN..Citizen of Washington.

MEMBERS EX OFFICIO OF THE INSTITUTION.

U. S. GRANT...............President of the United States.
S. COLFAX ....Vice-President of the United States.
S. P. CHASE...............Chief Justice of the United States.
H. FISH ....Secretary of State.
G. S. BOUTWELL ....Secretary of the Treasury.
W. W. BELKNAP.........Secretary of War.
G. M. ROBESON ....Secretary of the Navy.
J. A. J. CRESWELL......Postmaster General.
C. DELANO...............Secretary of the Interior.
A. T. AKERMAN..........Attorney General.
M. D. LEGGETT ....Commissioner of Patents.
H. D. COOKE.............Governor of the District of Columbia.

EXECUTIVE OFFICERS OF THE INSTITUTION.

JOSEPH HENRY, SECRETARY,

Director of the Institution.

SPENCER F. BAIRD, ASSISTANT SECRETARY,

In charge of Museum, Exchanges, &c.

WILLIAM J. RHEES, CHIEF CLERK,

In charge of Accounts, Printing, and General Business.

DANIEL LEECH, CLERK,

In charge of Correspondence.

CLARENCE B. YOUNG, CLERK,

And Book-keeper.

HENRY M. BANNISTER, CLERK,

In charge of Meteorological Records.

JANE A. TURNER, CLERK,

In charge of Records of International Exchanges.

SOLOMON G. BROWN, CLERK,

In charge of Transportation.

JOSEPH HERRON,

Janitor of the Museum.

PROGRAMME OF ORGANIZATION

OF THE

SMITHSONIAN INSTITUTION.

[PRESENTED IN THE FIRST ANNUAL REPORT OF THE SECRETARY, AND ADOPTED BY THE BOARD OF REGENTS, DECEMBER 13, 1847.]

INTRODUCTION.

General considerations which should serve as a guide in adopting a Plan of Organization.

1. WILL OF SMITHSON. The property is bequeathed to the United States of America, "to found at Washington, under the name of the SMITHSONIAN INSTITUTION, an establishment for the increase and diffusion of knowledge among men."

2. The bequest is for the benefit of mankind. The Government of the United States is merely a trustee to carry out the design of the testator.

3. The institution is not a national establishment, as is frequently supposed, but the establishment of an individual, and is to bear and perpetuate his name.

4. The objects of the Institution are, 1st, to increase, and 2d, to diffuse knowledge among men.

5. These two objects should not be confounded with one another. The first is to enlarge the existing stock of knowledge by the addition of new truths; and the second, to disseminate knowledge, thus increased, among men.

6. The will makes no restriction in favor of any particular kind of knowledge; hence all branches are entitled to a share of attention.

7. Knowledge can be increased by different methods of facilitating and promoting the discovery of new truths; and can be most extensively diffused among men by means of the press.

8. To effect the greatest amount of good, the organization should be such as to enable the Institution to produce results, in the way of increasing and diffusing knowledge, which cannot be produced either at all or so efficiently by the existing institutions in our country.

9. The organization should also be such as can be adopted provisionally; can be easily reduced to practice; receive modifications, or be abandoned, in whole or in part, without a sacrifice of the funds.

10. In order to compensate in some measure for the loss of time occasioned by the delay of eight years in establishing the Institution, a considerable portion of the interest which has accrued should be added to the principal.

11. In proportion to the wide field of knowledge to be cultivated, the funds are small. Economy should, therefore, be consulted in the construction of the building; and not only the first cost of the edifice should be considered, but also the continual expense of keeping it in repair, and of the support of the establishment necessarily connected with it. There should also be but few individuals permanently supported by the Institution.

12. The plan and dimensions of the building should be determined by the plan of the organization, and not the converse.

13. It should be recollected that mankind in general are to be benefited by the bequest, and that, therefore, all unnecessary expenditure on local objects would be a perversion of the trust.

14. Besides the foregoing considerations, deduced immediately from the will of Smithson, regard must be had to certain requirements of the act of Congress establishing the Institution. These are, a library, a museum, and a gallery of art, with a building on a liberal scale to contain them.

SECTION I.

Plan of organization of the Institution in accordance with the foregoing deductions from the will of Smithson.

TO INCREASE KNOWLEDGE. It is proposed—

1. To stimulate men of talent to make original researches, by offering suitable rewards for memoirs containing new truths; and,

2. To appropriate annually a portion of the income for particular researches, under the direction of suitable persons.

TO DIFFUSE KNOWLEDGE. It is proposed—

1. To publish a series of periodical reports on the progress of the different branches of knowledge; and,

2. To publish occasionally separate treatises on subjects of general interest.

DETAILS OF THE PLAN TO INCREASE KNOWLEDGE.

I. *By stimulating researches.*

1. Facilities afforded for the production of original memoirs on all branches of knowledge.

2. The memoirs thus obtained to be published in a series of volumes, in a quarto form, and entitled Smithsonian Contributions to Knowledge.

3. No memoir on subjects of physical science to be accepted for publication which does not furnish a positive addition to human knowledge, resting on original research; and all unverified speculations to be rejected.

4. Each memoir presented to the Institution to be submitted for examination to a commission of persons of reputation for learning in the

branch to which the memoir pertains; and to be accepted for publication only in case the report of this commission is favorable.

5. The commission to be chosen by the officers of the Institution, and the name of the author, as far as practicable, concealed, unless a favorable decision is made.

6. The volumes of the memoirs to be exchanged for the transactions of literary and scientific societies, and copies to be given to all the colleges and principal libraries in this country. One part of the remaining copies may be offered for sale, and the other carefully preserved, to form complete sets of the work, to supply the demand from new institutions.

7. An abstract, or popular account, of the contents of these memoirs to be given to the public through the annual report of the Regents to Congress.

II. *By appropriating a part of the income, annually, to special objects of research, under the direction of suitable persons.*

1. The objects and the amount appropriated, to be recommended by counsellors of the Institution.

2. Appropriations in different years to different objects; so that in course of time each branch of knowledge may receive a share.

3. The results obtained from these appropriations to be published, with the memoirs before mentioned, in the volumes of the Smithsonian Contributions to Knowledge.

4. Examples of objects for which appropriations may be made.

(1.) System of extended meteorological observations for solving the problem of American storms.

(2.) Explorations in descriptive natural history, and geological, magnetical, and topographical surveys, to collect materials for the formation of a physical atlas of the United States.

(3.) Solution of experimental problems, such as a new determination of the weight of the earth, of the velocity of electricity, and of light; chemical analyses of soils and plants; collection and publication of scientific facts accumulated in the offices of government.

(4.) Institution of statistical inquiries with reference to physical, moral, and political subjects.

(5.) Historical researches, and accurate surveys of places celebrated in American history.

(6.) Ethnological researches, particularly with reference to the different races of men in North America; also, explorations and accurate surveys of the mounds and other remains of the ancient people of our country.

DETAILS OF THE PLAN FOR DIFFUSING KNOWLEDGE.

I. *By the publication of a series of reports, giving an account of the new discoveries in science, and of the changes made from year to year in all branches of knowledge not strictly professional.*

1. These reports will diffuse a kind of knowledge generally interesting, but which, at present, is inaccessible to the public. Some of the reports may be published annually, others at longer intervals, as the income of the Institution or the changes in the branches of knowledge may indicate.

2. The reports are to be prepared by collaborators eminent in the different branches of knowledge.

3. Each collaborator to be furnished with the journals and publications, domestic and foreign, necessary to the compilation of his report; to be paid a certain sum for his labors, and to be named on the title-page of the report.

4. The reports to be published in separate parts, so that persons interested in a particular branch can procure the parts relating to it without purchasing the whole.

5. These reports may be presented to Congress, for partial distribution, the remaining copies to be given to literary and scientific institutions, and sold to individuals for a moderate price.

The following are some of the subjects which may be embraced in the reports :*

I. PHYSICAL CLASS.

1. Physics, including astronomy, natural philosophy, chemistry, and meteorology.
2. Natural history, including botany, zoölogy geology, &c.
3. Agriculture.
4. Application of science to arts.

II. MORAL AND POLITICAL CLASS.

5. Ethnology, including particular history, comparative philology, antiquities, &c.
6. Statistics and political economy.
7. Mental and moral philosophy.
8. A survey of the political events of the world; penal reform, &c.

III. LITERATURE AND THE FINE ARTS.

9. Modern literature.
10. The fine arts, and their application to the useful arts.
11. Bibliography.
12. Obituary notices of distinguished individuals.

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* This part of the plan has been but partially carried out.

II. *By the publication of separate treatises on subjects of general interest.*

1. These treatises may occasionally consist of valuable memoirs translated from foreign languages, or of articles prepared under the direction of the Institution, or procured by offering premiums for the best exposition of a given subject.

2. The treatises should, in all cases, be submitted to a commission of competent judges, previous to their publication.

3. As examples of these treatises, expositions may be obtained of the present state of the several branches of knowledge mentioned in the table of reports.

SECTION II.

Plan of organization, in accordance with the terms of the resolutions of the Board of Regents providing for the two modes of increasing and diffusing knowledge.

1. The act of Congress establishing the Institution contemplated the formation of a library and a museum; and the Board of Regents, including these objects in the plan of organization, resolved to divide the income* into two equal parts.

2. One part to be appropriated to increase and diffuse knowledge by means of publications and researches, agreeably to the scheme before given. The other part to be appropriated to the formation of a library and a collection of objects of nature and of art.

3. These two plans are not incompatible with one another.

4. To carry out the plan before described, a library will be required, consisting, 1st, of a complete collection of the transactions and proceedings of all the learned societies in the world; 2d, of the more important current periodical publications, and other works necessary in preparing the periodical reports.

5. The Institution should make special collections, particularly of objects to illustrate and verify its own publications.

6. Also, a collection of instruments of research in all branches of experimental science.

7. With reference to the collection of books, other than those mentioned above, catalogues of all the different libraries in the United States should be procured, in order that the valuable books first purchased may be such as are not to be found in the United States.

8. Also, catalogues of memoirs, and of books and other materials, should be collected for rendering the Institution a center of bibliographical knowledge, whence the student may be directed to any work which he may require.

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*The amount of the Smithsonian bequest received into the Treasury of the United States is	$515,169 00
Interest on the same to July 1, 1846, (devoted to the erection of the building)	242,129 00
Annual income from the bequest	30,910 14

9. It is believed that the collections in natural history will increase by donation as rapidly as the income of the Institution can make provision for their reception, and, therefore, it will seldom be necessary to purchase articles of this kind.

10. Attempts should be made to procure for the gallery of art casts of the most celebrated articles of ancient and modern sculpture.

11. The arts may be encouraged by providing a room, free of expense, for the exhibition of the objects of the Art-Union and other similar societies.

12. A small appropriation should annually be made for models of antiquities, such as those of the remains of ancient temples, &c.

13. For the present, or until the building is fully completed, besides the Secretary no permanent assistant will be required, except one, to act as librarian.

14. The Secretary, by the law of Congress, is alone responsible to the Regents. He shall take charge of the building and property, keep a record of proceedings, discharge the duties of librarian and keeper of the museum, and may, with the consent of the Regents, *employ assistants.*

15. The Secretary and his assistants, during the session of Congress, will be required to illustrate new discoveries in science, and to exhibit new objects of art. Distinguished individuals should also be invited to give lectures on subjects of general interest.

This programme, which was at first adopted provisionally, has become the settled policy of the Institution. The only material change is that expressed by the following resolutions, adopted January 15, 1855, viz:

Resolved, That the 7th resolution passed by the Board of Regents, on the 26th of January, 1847, requiring an equal division of the income between the active operations and the museum and library, when the buildings are completed, be, and it is hereby, repealed.

Resolved, That hereafter the annual appropriations shall be apportioned specifically among the different objects and operations of the Institution, in such manner as may, in the judgment of the Regents, be necessary and proper for each, according to its intrinsic importance and a compliance in good faith with the law.

REPORT

OF

PROFESSOR JOSEPH HENRY,

SECRETARY OF THE SMITHSONIAN INSTITUTION,

FOR 1870.

To the Board of Regents:

GENTLEMEN: The year 1870 may be considered almost an epoch in the history of the Smithsonian Institution, since in this year Congress commenced to recognize the propriety of making something like an adequate appropriation to relieve the Smithson fund from at least a portion of the burden to which it has from the first been subjected in the maintenance and care of the National Museum. During the last session of Congress an appropriation of $10,000 was granted for the preservation and exhibition of the national collection, and also $10,000 toward the preparation of the second story of the building for the better care and display of the specimens, and an equal sum for each of these objects has been asked at the present session for the year 1871, and we are assured by influential members of Congress that the request will be granted. It cannot be otherwise than gratifying to the friends of science that Government has at length awakened to the importance of making provision for the independent support of a National Museum, which we trust will be worthy of the capital of the United States. The connection which has heretofore existed between the National Museum and the Smithsonian Institution has been alike prejudicial to both, although more than one-half of the income of the Smithson fund has been expended in maintenance of the museum; and notwithstanding that the Institution, in the prosecution of its legitimate objects, has collected many thousands of specimens illustrating the productions of the North American continent, the public museum has not yet, owing to the inadequacy of means, been such as might be expected from the reputation of the Institution or the character of our Government.

The National Museum was established previous to the acceptance by the Government of the care of the Smithson bequest, and consisted at first of the specimens of natural history and ethnology collected by the United States exploring expedition under Admiral Wilkes. Unfortunately, from a misconception of the terms of the will of Smithson, as now generally recognized, Congress directed the appropriation of the income of the fund principally to a museum, a library, a gallery of art, and other local objects, which, though important in themselves, did not comport with the liberal spirit of the bequest, nor with the income of

the endowment, which was scarcely more than sufficient to properly support any one of these objects. Had it not been for this misconception, it is not improbable that before this time Congress would have made a more liberal provision for the support of the National Museum, and the scientific operations of the Institution which have made it favorably known throughout the world would have been much more extended. From the first the organic law of Congress has, therefore, stood in the way of the full development of the plan of active operations of the Institution; and it has only been by the gradual enlightenment of the public mind as to the true character of the will of Smithson and the importance of the plan of active operations, that, step by step, and after upward of twenty years of continued effort, the latter has now a fair prospect of producing all the results which have been claimed for it.

As stated in previous reports, the library of the Institution has been incorporated, under certain conditions, with that of Congress. The land around the building presented to the Institution by the Government, and upon which at first about $10,000 of the income of the fund was expended, has been incorporated with the public reservation set aside for a park, and the cost of its keeping defrayed from the general appropriation for the maintenance of the public grounds. The establishment of a gallery of art by the liberal endowment of Mr. Corcoran obviates the necessity of anything further being done in this direction by the Institution.

Still the emancipation of the fund from local objects is not as thorough as could be wished. It would be better, in my opinion, that the public museum should be entirely separated from the Institution. The appropriations of Congress are frequently fitful, and the distinction between appropriations for the museum and for the Institution is not as manifest as is desirable. It is the wiser policy of the Institution to ask no appropriations from Congress for its own legitimate objects, in order that it may be kept entirely free from political influence. We must, however, be content, in the attainment of an object depending upon legislative enactment, with securing a part of what we wish, if we cannot obtain the whole.

Finances.—The following is a general statement of the condition of the Smithson fund at the end of the year 1870, or rather at the beginning of the year 1871:

The amount originally received as the bequest of James Smithson, of England, deposited in the Treasury of the United States, in accordance with the act of Congress of August 10, 1846	$515,169 00
The residuary legacy of Smithson received in 1865, also deposited in the Treasury of the United States, in accordance with the act of Congress of February 8, 1867.....	26,210 63
Making the bequest of Smithson	541,379 63

Additions from savings, &c., also in the United States Treasury, as a part of the original fund	$108,620 37
In Virginia State stock, $72,760, valued at	48,000 00
Cash on hand	21,477 81
	719,477 81

The income from the fund during the year 1870, including the premium on gold, was $43,363 12. This amount is $6,152 08 less than that for 1869, due to the difference in the premium on coin.

No interest has been received from the State of Virginia for 1869 and 1870. Up to 1870 the usual appropriation from Government for the care of the National Museum was $4,000, but for the fiscal year commencing July 1, 1870, this amount was increased, as we have before stated to $10,000. Of this sum $5,024 have been placed to the credit of the museum; the whole expense, however, of keeping the museum, irrespective of the interest on the building, amounted to at least $15,000.

The remainder of the income (excepting $508 16) was expended in publications, exchanges, researches, salaries, &c., and nearly $5,000 for repairs on the building.

Congress also granted, as previously stated, an appropriation of $10,000 toward fitting up the large hall for the better preservation and display of the collections; but of this nothing has been drawn during the year, the plans and other preparations for the improvement of the building not having been completed. From the foregoing statement it will be evident that the Smithson funds are in a prosperous condition, and that should Congress continue annually to make an adequate support for the museum, they would be sufficient on the part of the institution to extend its usefulness far beyond what it has yet accomplished.

As a part of the history of the Institution, and in justice to the generosity of one of its earliest friends, I may mention under the head of finance, that for many years during the controversy which existed between the regents and the contractors in regard to the building, James M. Carlisle, esq., of this city, acted as counsel for the Institution, and has subsequently given advice on points of law which have arisen in conducting the various operations of the establishment. These services, the usual charges for which would amount to comparatively a large sum, have been gratuitously rendered to the Institution; for which liberality I would recommend a special resolution of thanks by the Board.

Publications.—The publications of the Institution are of three classes—the Contributions to Knowledge, the Miscellaneous Collections, and the Annual Reports. The first consist of memoirs containing positive additions to science resting on original research, and which are gener-

ally the result of investigations to which the Institution has in some way rendered assistance. The Miscellaneous Collections are chiefly composed of works intended to facilitate the study of certain branches of natural history or of meteorology, and are designed especially to induce individuals to engage in studies as specialties, to which in leisure moments their thoughts may recur, and by observations and collections in relation to which they may not only contribute to their own pleasure but, also, advance the cause of science. The Annual Reports are published at the expense of the Government, with the exception of the illustrations, which are furnished by the Institution.

During the past year the sixteenth volume of the Smithsonian Contributions to Knowledge has been published and distributed. It contains 494 pages, and is illustrated with 73 wood-cuts and 19 plates. The several articles contained in this volume, which were also published and distributed separately, are as follows:

The Gray Substance of the Medulla Oblongata and Trapezium, by John Dean, M. D. 4to, pp. 80. Sixteen plates, five wood-cuts.

Results of Meteorological Observations made at Brunswick, Maine, between 1801 and 1859, by Parker Cleaveland, LL.D. Reduced and discussed at the expense of the Smithsonian Institution, by Charles A. Schott. 4to, pp. 60. Eight wood-cuts.

Results of Meteorological Observations made at Marietta, Ohio, between 1826 and 1859, inclusive, by S. P. Hildreth, M. D.; to which are added Results of Observations taken at Marietta, by Mr. Joseph Wood, between 1817 and 1823. Reduced and discussed by the Smithsonian Institution, by Charles A. Schott. 4to, pp. 52. Fourteen wood-cuts.

On the Gliddon Mummy Case in the Museum of the Smithsonian Institution, by Charles Pickering. 4to, p. 6. One plate.

The Orbit and Phenomena of a Meteoric Fire-Ball, seen July 20, 1860, by Professor James H. Coffin, LL. D. 4to, p. 56. Two plates, two wood-cuts.

On the Transatlantic Longitude, by Benjamin Apthorp Gould. 4to, pp. 110.

The Indians of Cape Flattery, at the entrance to the Strait of Fuca, Washington Territory, by James G. Swan. 4to, pp. 118. Forty-four wood-cuts.

The Seventeenth volume of Smithsonian Contributions, that for the year 1871, has also been printed, is in the hands of the binder, and will soon be ready for distribution. It consists of a single memoir of 602 quarto pages, presenting the result of an elaborate original investigation by Lewis H. Morgan, esq., of Rochester, New York, on the "Systems of Consanguinity and Affinity of the Human Family."

This memoir, of which an account has been given in a previous report, was first referred to a commission consisting of Professor J. H. McIlvaine and Professor William Henry Green, of Princeton, New Jersey, who recommended its publication, but advised certain changes in the method of

presenting the subject. After these modifications had been made, it was submitted to the American Oriental Society, and was by it referred to a special committee, consisting of Messrs. Hadley, Trumbull, and Whitney, who, having critically examined the memoir, reported that it contained a series of highly interesting facts, which, they believed, the students of philology and ethnology, though they might not accept all the conclusions of the author, would welcome as valuable contributions to science.

The investigations of Professor Newcomb, relative to a new orbit of the planet Uranus, in continuation of those relative to the planet Neptune, an account of which was given in previous reports, have been temporarily interrupted by the visit of the author to Europe to observe the total eclipse of last December, and to collect ancient observations for correcting the mean motion of the moon. These investigations were commenced as far back as 1860, but Professor Newcomb had so little time to spare from official duties, and had to depend so much upon himself on account of the methods to be employed, that four years elapsed before even the first formulæ for the perturbations were computed. The best accepted elements of the planets were first used, viz, those of Bouvard for Jupiter and Saturn, and those of Pierce and Kowalski for Neptune. The calculated places of Uranus and Neptune were found from these data to differ so widely from the true ones given by observation as to show that the elements of these planets which had been adopted were not to be relied on. A re-investigation of their orbits therefore became necessary. That of Neptune was made exhaustive. The magnitude of the corrections required in the old elements is shown by the fact that the longitude of the perihelion of Neptune was changed by about four degrees. This investigation was published by the Institution in 1865, and the tables for predicting the position of the planet were immediately adopted by the nautical almanacs of England, Germany, and this country, and afterward by that of France, so that the computations of Neptune's motion are now generally made from them.

The elements of Uranus were next so far corrected by a preliminary investigation, that, with the perturbations already computed, the motion of the planet from the time of its discovery in 1781 until 1862 was represented within a very few seconds of arc. On collecting the perturbations of Saturn there appeared to be considerable discrepancy between the old ones employed in Bouvard's tables and those since computed by Hansen. As there could be little doubt of the correctness of the latter, Professor Newcomb accepted them as the basis of a preliminary investigation of the orbit of Saturn, and obtained elements which represented its motion near enough for the purpose desired. The elements of Jupiter were found to be sufficiently near the truth. The old computations of the "first-order" of perturbations were then corrected, and to guard against the possibility of an error the perturbations were then recomputed by an entirely different method. After long study and labor

the author was enabled to devise a method more simple than any before employed, of which the quantities previously calculated furnished the basis, and which has the great advantage of being easily applicable to the perturbations of the second order. The results of the two computations have been found to agree very closely. The more important terms of the second order have been once computed, but will be gone over again to insure correctness. The most difficult part of the work is now completed. An appropriation has been made by the Institution for defraying the expense of the clerical labor which is required in preparing the tables and performing the other laborious arithmetical calculations necessary in reducing the abstract mathematical results to practical use.

Among the papers accepted for publication are three by Major General J. G. Barnard, United States Army. The first of these relates to the "Precession of the Equinoxes and Nutation as identified with the phenomena of the Gyroscope." All writers who explain the "Precession" in a manner intended to be more or less adapted to popular comprehension, assume or demonstrate certain elementary facts which are common to the general phenomena of the "Precession," and the movements of the philosophic toy, the "Gyroscope." The intention of this paper is to identify the phenomena, and to show that a common analysis leads, when properly adapted to the different circumstances, to their solution. As a matter of course, the introduction of the proper expressions for the external forces into the general equations of rotating bodies will give the particular equations for the special cases. In the Mécanique Céleste, are thus derived the expressions for precession and nutation; but the analytical process is difficult, and the point of identification of the phenomena with those of the gyroscope is, in this point of view, too remote to be interesting. In this paper, solutions primarily obtained for the gyroscope are subsequently made use of to develop all the facts of precession and nutation. By the methods employed it is incidentally shown that the phenomena of "deviation" in rifled projectiles may be explained.

The second paper by General Barnard is on the motions of a "freely suspended pendulum," and differs from other well known discussions of this problem in giving, as a preliminary, a simple explanation of the origin of the forces which, on the surface of the rotating earth, cause a progressive azimuthal motion of the plane of vibration; and furnishing the analytical expressions for these identical with those of Poisson obtained by other processes. These same expressions exhibit forces which more or less sensibly affect *all* motions of material bodies on or near the earth's surface, as *e. g.* the tidal currents, the winds, the trajectories of projectiles, &c. The expressions obtained for the pendulum are developed with much greater detail than has been done in previous works. The differential expressions for the vibrations of the so-called "spherical pendulum" are integrated by development into series, and expressions approximately accurate, obtained for the

azimuthal motion of the apsides of the quasi-elliptical orbit. Inasmuch as in all actual experiments with the freely suspended pendulum the vibrations soon assume the "spherical" character, these latter expressions are really important as corrections to the azimuthal motion properly due to the earth's rotation, and may explain the small variations from the latter which the experiments generally exhibit. It is believed that these corrections have never before been applied, or indeed actually put into simple analytical shape. It is further shown that if a freely suspended pendulum is made to swing through a great circle with very high velocity, the plane of its orbit remains invariable in direction, in space, and that in this phase the phenomenon is identical with that shown by a gyroscopic disk, as it was arranged by Foucault to exhibit the rotation of the earth.

A third paper by the same author is "on the Phenomena of Precession and Nutation as affected by the internal structure of the earth," and is an attempt to corroborate the dictum of Sir William Thompson, that the phenomena of the precession and nutation *do* authorize some conclusions—very limited, indeed—concerning the internal structure of the earth, inasmuch as it is proved that the very commonly received geologic hypothesis of a thin crust enveloping a molten fluid is inconsistent with the actual phenomena as observed.

As the basis of the argument, the theorem is analytically demonstrated that an entirely fluid earth (*i. e.*, entirely destitute of solid crust and without internal viscidity) would exhibit neither precession nor nutation. In other words, that the tilting effects of the solar and lunar attractions would be exactly neutralized by the centrifugal forces due to the tidal protuberances they develop. *Pari ratione*, if the *figure* of the earth yields *at all* to the attractions, the precession and nutation will be neutralized in exact proportion to the extent (as compared with a perfect fluid globe) to which that yielding obtains.

Sir W. Thompson has proved that even an earth entirely *solid must yield*, unless its rigidity to the depth of two or three thousand miles greatly exceeds that of steel; a *thin crust*, say thirty or forty miles thick, such as geological hypothesis attributes to the earth, if enveloping a fluid nucleus, would yield nearly as much as if the earth were entirely fluid. But the observed rates of precession and nutation conform almost exactly to the hypothesis of perfect rigidity. Hence, the hypothesis of a thin crust is *untenable*. Incidentally the fallacy of the experiment (with rotating spherical glass shells, containing water) and argument of M. Delaunay to invalidate the conclusions of Professor Hopkins and Professor Thompson is exhibited, and the opinions of Poisson concerning the internal structure of the earth are, according to the author, shown to coincide better with observed facts than those of any other physicist.

Another paper has been examined and accepted for publication entitled "The Secular Variations of the Orbits of the Planets," by John

N. Stockwell. If but one planet revolved around the sun its path in space would be a true ellipse, which would always be the same in form and position; but if several planets revolve at the same time around the central body, their mutual attraction will disturb the regularity of the elliptical motion. The mutual action of the planets on each other produces two classes of disturbance, one of which consists in a change of the motion of each planet in its elliptical orbit, in some parts of its path moving faster and in others slower than it would if undisturbed; the other consists of a change in the form and relative position of the elliptical orbit. The first is called the periodic inequalities, and the second the secular variations. They are, however, both periodical, though the first runs through its changes in a short time, while the latter requires centuries to complete its cycle. The object of the investigations of Mr. Stockwell is to determine the numerical value of the secular changes of the elements of the orbits of the planets of our system. Several partial solutions of this problem have been obtained by previous authors, but they have been approximations based upon data less perfect than that which is at present afforded in the discovery of the new planet Neptune, and the better determination of the masses of the other bodies composing our system.

The expense of the publication of this paper is defrayed by the liberal donation of $1,200 from a friend of science, who declines to allow his name to be mentioned. We cannot, however, permit the fact to pass unnoticed of this example of the high appreciation of the value of abstract science since it does honor to the intelligence and liberality of one of our citizens engaged in active business life, and may serve as an example to stimulate other donations of a similar character.

In several of the previous reports mention has been made of a grammar and dictionary of the Choctaw language, in process of preparation for the Institution by Dr. Byington, for many years a missionary among the Choctaw Indians. This work was finally submitted to the Institution for publication, but having been found on examination to require corrections it was returned to the author in order that these might be made. Before, however, this work was completed, Dr. Byington died, and his MS. was given for revision to Dr. Brinton, of Philadelphia. It was again submitted to the Institution and referred to a commission for critical examination. Dr. Brinton, however, not satisfied with the report of this commission, withdrew the memoir, and presented it to the American Philosophical Society, in whose transactions it has since been printed. No objection was made on the part of the Institution to this transfer, since it has been from the first a part of its policy never to expend any portion of its funds in doing that which can be done by other means.

It will be remembered that in 1867, at the suggestion and expense of the Institution, a geological exploration of a portion of the Louisiana coast was made by Professor E. W. Hilgard, of the University of Mis-

sissippi, mainly with a view to ascertain the geological age and mode of occurrence of the rock-salt deposit of Petite Anse. In the absence of definite data concerning the general geology of Louisiana, his observations on the formations of the coast (an abstract of which was published in the American Journal of Science, January, 1869) demonstrated, so far as the salt deposit was concerned, only the fact that in point of age it was anterior to the drift. The impulse thus given to geological research in Louisiana, however, soon led to further explorations. By subscription, and a special appropriation obtained from the commissioners of immigration of the State, the New Orleans Academy of Sciences raised a fund for the purpose of enabling Professor Hilgard to make a general geological reconnaissance of Louisiana, which was executed in May and June, 1869. This enabled him to communicate to the American Association for the Advancement of Science, at its Salem meeting, a general sketch of the geology of Louisiana. Almost simultaneously with the organization of Professor Hilgard's second exploration, steps were taken by the faculty of the University of Louisiana to secure legislative aid for a geological and physical survey of the State. The latter is now in progress, and the second annual report on the work will soon be published.

As regards the rock-salt deposit, Professor Hilgard's observations in Northern Louisiana point to the conclusion that it is but one of a series of cretaceous outliers, traversing the State in a northwest and southeast direction, and indicating the existence of an ancient ridge which must have exerted an important influence upon the physical conformation of the Lower Mississippi Valley. The remarkable gypsum and sulphur deposits of Calcasieu are likewise, in his opinion, referable to the same age. Professor Hilgard has nearly completed a final memoir on the geology of the Petite Anse region for publication by the Institution; the results of his simultaneous exploration of the Lower Mississippi and delta having been communicated to the American Association at the Troy meeting, and subsequently presented to the American Journal of Science.

Dr. Horatio C. Wood, of Philadelphia, having completed an elaborate work on the fresh-water algæ, principally of microscopic forms, presented it to the American Philosophical Society and also to the Academy of Natural Sciences of Philadelphia, but the expense of publication prevented either of these societies from undertaking it. It was therefore offered to this Institution, and after a critical examination has been accepted for publication. As a systematic description of the fresh-water algæ of North America it will form a complement to the great works on the marine algæ, by Dr. Harvey, published some years ago by the Smithsonian Institution. It will be copiously illustrated by drawings, made principally under the microscope and will serve to illustrate an obscure department of botany, as well as to furnish the means by which investigators of minute microscopic organisms may make the

comparison of fossil and recent forms, a subject which is now attracting much attention in Europe and America.

The eighth volume of Miscellaneous Collections contains the following papers:

1. Monographs of the Diptera of North America. Part IV. Prepared for the Smithsonian Institution by R. Osten Sacken. 8vo, pp. 358. Four plates and seven wood-cuts.

2. Catalogue of the Orthoptera of North America described previous to 1867. Prepared for the Smithsonian Institution by Samuel H. Scudder. 8vo, pp. 110.

3. Land and Fresh-water Shells of North America. Part I. Pulmonata Geophila. By W. G. Binney and T. Bland. 8vo, pp. 328, and 544 wood-cuts.

4. Arrangement of Families of Birds. Adopted provisionally by the Smithsonian Institution. 8vo, pp. 8.

5. Circular to Officers of the Hudson's Bay Company. 8vo, pp. 6.

6. Suggestions relative to Objects of Scientific Investigations in Russian America. 8vo, pp. 10.

7. Circular relating to Collections in Archæology and Ethnology. 8vo, pp. 2.

8. Circular to Entomologists. 8vo, pp. 2.

9. Circular relative to Collections of Birds from Middle and South America. 8vo, pp. 2.

10. Smithsonian Museum Miscellanea. Pp. 88.

The ninth volume of Miscellaneous Collections contains—

1. Bibliography of North American Conchology previous to the year 1860. Prepared for the Smithsonian Institution by W. G. Binney. Part II. Foreign Authors. 8vo, pp. 302.

2. Catalogue of Publications of Societies and of Periodical Works belonging to the Smithsonian Institution. Deposited in the Library of Congress, 1866. 8vo, pp. 596.

In accordance with the plan adopted by the Institution of furnishing facilities and means of identifying specimens of natural history in its different departments, an arrangement was made with Professor De Saussure, of Geneva, Switzerland, the highest authority on the class of insects known as hymenoptera, (of which the principal forms are wasps, bees, &c.,) to prepare a monograph of this part of entomology. Large collections have been sent to him for the work, to which he has devoted several years of gratuitous labor. The first part of the manuscript was completed in the French language in 1863, and for translation was placed in the hands of a competent entomologist, Mr. Edward Norton, of Farmington, Connecticut, who volunteered his services from a desire of advancing science. This part of the memoir was prepared for the press in 1864, but as Mr. Norton was obliged to be absent from the country several years, the printing was delayed until his return, in order that the proof-sheets might be properly corrected. By this time, however,

so much new material had been collected it was thought advisable to refer the work anew to Professor De Saussure, from whom it has again been received, and after having been a second time revised by Mr. Norton will soon be sent to the press.

The Institution in carrying out its original plan of the preparation of manuals of natural history, has thus made provision for publications on the coleoptera, lepidoptera, neuroptera, diptera, orthoptera, and hymenoptera. Of the few remaining orders, a similar monograph of the *hemiptera*, by P. R. Uhler, esq., has been prepared, and will be published when the funds will permit.

For many years the Institution has intended, in consequence of the scattered nature of the accounts of the botany of the region west of the Mississippi, and the absence of any text-book in which correct descriptions could be found, to publish a complete list of the plants, with all the synonyms and species. For a working botanist, engaged in the study of our western plants, the search for what has been written takes more time and labor than all the rest of his work, besides which there is always the probability of overlooking some writings of importance. The design has not heretofore been carried out, on account of the pressure of other operations, but recently the great need of this aid to botanical research having been urged on the Institution by some of the principal botanists of the country, arrangements have been made with Mr. Sereno Watson, of New Haven, to prepare the work in question. The expense of preparation will be borne by private subscription, the Smithsonian Institution paying for the clerical labor and for the publication. Mr. Watson is esteemed highly competent for the duty intrusted to him, and is favorably known from his labors as botanist of the exploration of the fortieth parallel, under Clarence King, esq. Good progress has been made in the work, and during the year we expect the manuscript to be completed.

In still further pursuance of the plan initiated by the Institution of furnishing aids for the arrangement of collections, as illustrated by its series of check-lists of specimens, an article by Professor Theodore Gill is in process of publication, entitled "An Arrangement of the Families of Mollusks." His system has been adopted provisionally as that by which the extensive collections of the Smithsonian shells are to be arranged and has been approved by some of the principal zoölogists of the country. To extend its benefits, and furnish a similar guide to other museums, the list embraces families, recent and fossil, accepted by the best naturalists of the day, although embodying results of special investigations made by Professor Gill and Mr. Dall at the Institution.

The Annual Report for the year 1869 was printed as heretofore, by order of Congress, but there was a reduction of one thousand in the number of extra copies usually furnished to the Institution. This reduction must have been the result of inadvertence, as we have long urged upon Congress the great demand for the document as a reason

for the increase of the edition, and have been assured by many Senators and Representatives that this would be made. The applications for the report have become so numerous that it is impossible to supply all who are entitled to receive it. In this connection the propriety should be urged upon Congress of ordering new editions of such of the reports as have been stereotyped. The printing of these could be done at very little expense, and would enable the Institution to furnish volumes, for which there is daily application from members of Congress in behalf of libraries and public institutions, to complete sets of the series.

In addition to the report of the Secretary, giving an account of the operations, expenditures, and condition of the Institution for the year 1869, and the proceedings of the Board of Regents, it contains the following articles: Memoirs of Kepler, Thomas Young, Auguste Bravais, C. T. P. Von Martius, and Stefano Marianini; an original paper on the chemistry of the earth, by T. Sterry Hunt; articles on the electrical currents of the earth; phenomena of flight in the animal kingdom; the northern seas; report on the transactions of the Society of Physics and Natural History of Geneva; an original article relative to Coronado's march in search of the seven cities of Cibola, and a discussion of their probable location; social and religious condition of the lower races of man; principles and methods of palæontology; remarks on the Cara Gigantesca of Yucatan; forests and their climatic influence; meteorites; remarkable forms of hail-stones in Georgia; eruption of the volcano of Colima. It is proper to remark that the article on the flight of birds was translated from the French by Mr. W. H. Dall, whose name was accidentally omitted at the head of the article.

For the purpose of forming a general map of the North American Continent, exhibiting the plains, mountains, valleys, &c., the Smithsonian Institution has collected a large amount of material relative to *altitudes*, which has been placed in the hands of W. L. Nicholson, esq., topographer of the United States Post Office Department, to be discussed and elaborated.

There must, however, still remain in the hands of individuals and corporations records of an important character, which would be of great value in properly carrying out the enterprise. The correspondents of the Institution are requested to send to it printed copies or original manuscripts of records, especially of plotted profiles or maps, pertaining to this subject.

In stating the heights, as furnished by surveys for railroads, whether actually constructed or only projected, it is desirable that the levelings be referred to some known point on connecting or intersecting roads, or to the water-surface (high water, low water, or mean tide) of the ocean or of one of the great lakes, or to the level of a noted stage of water (high or low) of some river. The crossings of the water-courses, ridges, and summits are particularly desired, as well as all considerable and characteristic changes of level, giving, where much difference exists,

both grade-line and original surface; the levels of all intersections with other roads are important as means of comparison, and for checking results. Due credit will be given to all contributors to this work.

Exchanges.—The system of international exchanges, established by the Institution, has been continued with unabated zeal during the past year. The number of foreign establishments to which the Smithsonian and other publications are distributed, and from which returns are received now amounts to over seventeen hundred. It includes not only all the first-class libraries and societies which have established a reputation, but also a large proportion of the minor institutions of the Old World. The following table exhibits the number of foreign institutions in each country with which the Smithsonian Institution is at present in correspondence:

Sweden	19	Turkey	10
Norway	11	Africa	14
Iceland	2	Asia	30
Denmark	25	Australia	25
Russia	154	New Zealand	10
Holland	59	Polynesia	1
Germany	529	South America	31
Switzerland	54	West Indies	6
Belgium	119	Mexico	5
France	80	Central America	1
Italy	141	British America	27
Portugal	5	General	5
Spain	9		
Great Britain and Ireland	286		1,744
Greece	6		

During the year 1870, 1,805 packages, containing many thousand different articles, were transmitted to foreign countries. These packages were contained in 121 boxes, having a cubical content of 1,189 feet, and weighing 31,383 pounds. The parcels received at the Institution for parties in this country numbered 3,705. The separate volumes contained in these parcels would largely increase the number, the Institution having received 5,182 articles for its own library. The war between France and Germany, which commenced in July, affected, in some degree, the number of packages received from these countries, and it is probable that the result of this unfortunate conflict will be still more marked in the diminution of the number of scientific publications which may be received from Europe in the year 1871. The Smithsonian packages are passed through all the custom-houses of the world free of duty. The only exception which existed at the date of the last report was that of Italy, and through the intervention of the American minister, Hon. Mr. Marsh, the Italian government has since granted the same privilege.

As in previous years, the Institution has received great benefit from the privileges of free freight for its packages, accorded by a large number of steamboat and railroad lines of transportation. In this report, as in former ones, reference should be made to the liberality of the Pacific Mail Steamship Company; of the Panama Railroad Company; of the Pacific Steam Navigation Company; of the New York and Mexican Steamship Line; of the New York and Brazilian Line; of the North German Lloyds; of the Hamburg American Packet Company; of the French Transatlantic Company; of the Inman Line; and of the Cunard Line. I am happy to announce that to the foregoing list is to be added the Anchor Line of steamers between New York and Glasgow, of which Messrs. Henderson & Brother are the New York agents; and I would recommend that an official acknowledgment be made, on the part of the board, to these gentlemen for their courtesy in offering to the Institution the same privileges accorded by the other New York lines. The Union Pacific Railroad Company has granted free transportation, although thus far we have not been able to avail ourselves of the privilege. The Adams Express Company also continues its liberal policy in regard to our freight. It would be quite impossible for the Institution, without the aid thus liberally afforded, to carry out, in its full efficiency, its system of international exchanges, which, by facilitating the intercourse of scientific institutions and of students throughout the world, constitutes one of its most important features.

It is also my duty, as well as a great personal gratification, to inform you of the liberality of several of these companies, extended to myself on the occasion of the visit to Europe which I made during the past summer, in obedience to your authority; the agents of the North German Lloyds, Messrs. Schumaker & Co., of Baltimore, and Messrs. Oelrichs & Co., of New York, as well as Mr. C. G. Francklyn, the agent of the Cunard steamers, having offered me a free passage across the ocean.

Library.—As in previous years, large accessions have been made to the library of the Institution, principally through the system of international exchanges. The following is a statement of the number of books, maps, and charts received during 1870, most of which have been deposited in the National Library in accordance with the arrangement entered into several years ago, and fully explained in preceding reports:

Volumes:		
Octavo or less	842	
Quarto or larger	270	
		1,113
Parts of volumes:		
Octavo or less	1,263	
Quarto or larger	561	
		1,824

Pamphlets:		
Octavo or less	1,764	
Quarto or larger	302	
		2,066
Maps and charts		179
Total receipts		5,182

The following are some of the larger donations received in 1870:

From the ministry of the interior, Christiania, Norway, "Den Norske Lods;" 2 volumes, octavo, and 71 charts.

From the Imperial Botanical Garden, St. Petersburg, "Sertum Petropolitarum seu icones et descriptiones plantarum quæ in Horto Botanico Imperiali Petropolitano floruerent." Parts I and II, 1846; III and IV, 1869. Folio.

From His Majesty the King of Prussia, "Danzig und seine Bauwerke in malerischen Original-Radirungen mit geometrischen details und text, Von Johann Carl Schultz;" volumes I–III, oblong folio.

From Dr. Koch, Berlin, 127 pamphlets, University Theses.

From the Royal Public Library, Dresden, "Riedel's Codex Diplomaticus Brandenburgensis;" 41 volumes, quarto.

From the Agricultural Association, Potsdam, "Zeitschrift;" volumes III–XVIII, octavo. "Monatschrift," volumes XIX–XXIII, octavo; and "Amtliches Vereinsblatt," 1869, quarto.

From the Austrian government, "Reichs-Gesetz-Blatt für das Kaiser thum Oesterreich;" 1849–1869, quarto, 21 volumes.

From the Musée de Douai, "Dictionnaire des Sciences Médicales;" volumes I–LX, quarto.

From the minister of public instruction, Florence, 11 volumes "On Education, Public and Private."

From the minister of public works, Florence, 25 volumes and 16 pamphlets. Hydraulics, Navigation, and Engineering, &c.

From the meteorological office, London, "Daily Weather Reports," July 1, 1868, to June 30, 1870, (4 volumes and 6 parts,) folio; and "Quarterly Weather Report," part I.

From William Blackmore, esq., Liverpool, "Hoare's Ancient History of Wiltshire," volumes I and II, folio, beautifully illustrated with maps and plates. "The People of India: A series of photographic illustrations, with descriptive letter-press;" volumes I–IV, 1868, quarto. "Tree and Serpent Worship, or Illustrations of Mythology and Art in India in the First and Fourth Centuries after Christ;" quarto; and various other works.

From the State of Illinois, State documents, 14 volumes.

The incorporation of the library of the Institution with that of Congress continues to be productive of the results which were anticipated from this union. The extensive series of transactions of learned

societies, the number of sets and volumes of which are constantly increasing through the Smithsonian exchanges, is an important feature of the National Library, while the use of the books on special subjects belonging to the Government greatly enlarges the facilities for investigation of the collaborators of the Institution. From the first a harmonious co-operation has existed between the two establishments, and on all occasions we have found Mr. Spofford, the accomplished librarian of Congress, ready to consult the interests of the Institution, and insert on his list of purchases any work which we might indicate as desirable for scientific research. Professor Gill, formerly in charge of the Smithsonian library, and now one of the principal assistants in the Library of Congress, still continues his connection with the Institution, and in spending, as he does, most of the hours unemployed in official duty in scientific research at the Smithsonian building, affords the means of constant communication.

The National Library is rapidly increasing in value, both in regard to the number and the character of the books which are annually added to its collections. The sources of increase are, first, the books purchased by the liberal appropriation of Congress; second, the Smithsonian exchanges; and, third, the deposit of books in accordance with the copyright law. From this last source it has lately received a very large addition of all the American works secured by copy-right since the first enactment of the copy-right law, and previously in charge of the Secretary of the Interior. These books exhibit the phases of thought and the progress of the mental activity of this country for nearly half a century, and have, therefore, a special value independent of their literary or scientific character.

At the time of the organization of the Smithsonian Institution, Congress directed that in order to secure the right of authorship of a book three copies of it should be deposited as evidence of title, one in the library of the Institution, another in that of Congress, and a third in the office of the United States district court. In the case of a costly work, perhaps in several volumes, this was a tax on the author or publisher for the protection of his property which was not improperly considered oppressive. From considerations of justice, therefore, as well as of a prudent regard to the cost of the care of these books, the Smithsonian Institution was the first to petition Congress that the law might be so modified that only two copies should be required to be deposited as evidence of title, and these in the Library of Congress. The proposition suggested in this petition was adopted, and I believe the law enacted in accordance with it now meets with general approbation. It is of some importance that this fact should be mentioned, because copies of books are still occasionally sent to the Institution from a want of a knowledge of the existing law.

Besides the general library of the Government in the Capitol each of the separate Departments, as well as several of the bureaus, has a spe-

cial library. When we add to these the Washington Library and that of the Young Men's Christian Association, the aggregate of the books in the city of Washington must be greater than that in any other city in the country in proportion to the population. Unfortunately, however, these collections are not at present as readily accessible to the public as could be desired. The rapid increase, however, of the National Library will soon render the erection of a separate building absolutely necessary, and in the new arrangement which will result from this, the different libraries can, perhaps, be brought into harmonious relation, and while provision is afforded for the accommodation of a much larger number of readers, the number of hours during which the books are accessible may be increased.

Explorations and collections.—The Institution has continued, during the past year, as heretofore, to prosecute researches and explorations in ethnology and natural history, both by detailing special agents for particular work, and by co-operating with private individuals and Government expeditions, in securing the desired result.

Among the more important of the first-mentioned class was an investigation among the mounds of Tennessee, under Mr. J. P. Stelle. This gentleman spent a number of months in examining carefully several groups of ancient mounds, and has furnished an interesting account of his researches, accompanied by topographical drawings of the localities, and large numbers of specimens, obtained in the course of his explorations. The report of Mr. Stelle will be printed in the appendix to the annual report of the Institution.

Professor Baird, during his visit to Wood's Hole, in Vineyard Sound, continued his investigations of previous years among the shell-heaps of the coast, and added largely to the collection in archæology. He also devoted much attention to the study of the habits of the marine fishes of that part of the coast. Under the special direction of Professor H. E. Webster, a system of dredging was carried on in the same locality, from which an interesting series of mollusca and other marine animals was procured.

Captain Dow, of the Panama Railroad service, has furnished important collections from Central America, among them the skulls of what will probably prove to be a new species of tapir. Mr. Durkee, of Wyoming Territory, has supplied a large number of specimens of nests and eggs, with fossils and other objects from his locality, embracing several species not before in the collection.

The largest collections, however, received during the year, are those made by Professor Hayden, as United States geologist for the Territories. These, in accordance with the law of Congress making the Institution the depository of all objects of nature and art, natural history, etc., belonging to the United States, have been sent from time to time to the Institution, forming an aggregate of about sixty boxes, and em-

bracing large numbers of new species of fossil mammals, reptiles, and fishes, with other interesting objects.

Mr. R. McFarlane, Mr. James Lockhart, and Mr. Strachan Jones, who have been extremely liberal to the Institution in previous years, have again made important additions to its store of specimens, illustrative of the natural history of the region of the far northwest.

In accordance with the understanding between the Institution and the Medical Department of the Government, the specimens of human crania obtained by us have been transferred to the Army Medical Museum, which has, in turn, sent to the Institution all other articles it had received in ethnology and archæology. By this means a very extensive and valuable series of specimens has been obtained by the Institution during the past year. A full list of the additions thus made, will be found in the appendix to the present report.

Another collection worthy of special mention was presented to the Institution by the Colonial Museum, at Wellington, New Zealand. This consisted of bones of the *Dinornis*, the skins and skeleton of the *Apteryx*, skins of other birds, shells, and ethnological specimens of the country, and was partly in return for a valuable series of books presented by the Institution to the colonial government.

The labors of Dr. Edw. Palmer, already well known in connection with the ethnological museum of the Institution, have been continued during the present year, and large numbers of articles of Indian manufacture, both ancient and modern, attest his zeal and success as a collector. A more detailed report will be made upon these when the entire collection is received. Lieutenant Ring, of the Army, has continued his valuable donations from Alaska, embracing specimens of animals as well as Indian relics of great antiquity. From Captain C. M. Scammon, of the United States revenue marine, we have received a number of specimens and several important communications in reference to the seals and whales of the Pacific coast. A memoir submitted by this gentleman to the Institution has been published by the Philadelphia Academy of Natural Sciences, and is considered an important contribution to the knowledge of the subject already existing. Dr. G. M. Sternberg and his brother, Mr. C. H. Sternberg, have transmitted extensive and valuable collections of the tertiary fossil plants of Kansas, and other objects of interest. The former have been found, on examination by Mr. Meek, to contain a number of new species, which will shortly be described.

It will be remembered that an exploration of the Isthmus of Tehuantepec, by Professor Sumichrast, has been in progress for some years past, under the direction of the Institution, the expense of which was defrayed in part by the Kentucky University at Lexington, by the Boston Society of Natural History, and by the Academy of Natural Sciences of Philadelphia. The labors of Professor Sumichrast were brought to a close during the past summer, and several of the collaborators of the Institution are now at work in investigating particular

branches of the collection with a view to prepare reports on them. The birds of the collection are in charge of George N. Lawrence; the insects, of Mr. Scudder; the shells, of Mr. Bland; and the reptiles and fish, of Mr. Cope. The series is very complete, and is believed to express essentially the zoölogical character of an interesting portion of Mexico. As specially noteworthy in this connection, is the donation by the Imperial Zoölogical Museum of Vienna, of the skin and skeleton of the European aurochs. This animal, according to Professor Baird, is a species of bison, and very closely related to the American buffalo, if, indeed, it be not, as some naturalists assert, the same. It was formerly found in abundance in Europe, and is mentioned by Cæsar, Tacitus, and other classical writers. It has been almost entirely exterminated, existing at the present time only to the number of a few head in Lithuania and in the Caucasus. The European specimens are preserved with jealous care by the Russian authorities, and severe penalties are imposed for killing or even injuring them.

The number of donations to the collection of the Institution received during the past year is so large that we find it impossible at this time to give to each that special mention which it deserves. A list of them, however, with the names of the donors, will be found in the appendix to the present report; and I embrace this opportunity to express the thanks of the Institution to all who have thus aided in furthering its objects, and to invite their kind co-operation for the future.

The usual statistics in regard to the number of specimens catalogued during the year, and the extent to which the distribution of duplicates has been made, will be found in the accompanying tables. It will be seen that the average of the past years has been fully maintained, and that as far as the material and force at the command of the Institution would permit, the work has been faithfully carried on.

The museum.—Congress having made an appropriation for the better display of the specimens belonging to the Government, it becomes a matter of importance to carefully consider the character which is to be given to the national museum. There is scarcely any subject connected with science and education to which more attention is given at the present day than that of collections of objects of nature and art, known under the general denomination of museums. This arises from their growing importance as aids to scientific investigation and instruction. As they are intended to subserve different ends they are of different characters. There are, on the one hand, large central museums supported by Government appropriations, and on the other, local museums which are established and sustained by societies and voluntary individual aid. The latter are established in almost all parts of the Old World, and are becoming somewhat numerous in this country. The special aim of the directors of these should be to make full collections of all the objects of natural history in their vicinity, not only for the instruction of

the members of the society, and to diffuse a taste for the refined, intellectual pleasure, which is derived from the minute observation of the natural world, but also to furnish lists of local floras and faunas, and of mineralogical and geological localities which may serve to establish the area of distribution of special objects of nature, and thus contribute to the extension as well as the diffusion of knowledge. The directors of museums of this character ought to be careful not to attempt to form general collections, other, perhaps, than a limited number of specimens for comparison, since it will soon be found that the cost and labor of the proper care and exhibition of the local collections will equal the means which can be commanded for this purpose.

Large museums or collections supported by Government appropriations are of different characters, in accordance with the objects they are designed to subserve. They may be intended exclusively for scientific research, and for this purpose consist of large numbers of specimens and duplicates, as it were, of the raw materials of science, which have never been investigated, but which may serve for the study, of the productions of entirely unexplored regions. It has been the policy of this Institution to make collections of this kind, to submit them to experts for critical examination, and to publish such descriptions as would render them subservient to the progress of scientific generalization. If these descriptions were exhaustive, the original specimens would no longer be required for further scientific investigation; but, unfortunately, the characteristics and peculiarities of the specimens are only partially recognized and represented at any one period, and hence it becomes necessary from time to time to go over the same ground in order to verify or disprove new and ingenious suggestions as to peculiarities and relations not hitherto recognized; the specimens must therefore be preserved, especially if they are of such a character as cannot readily be replaced. In making such collections the Smithsonian Institution has done, perhaps, more than any other establishment during the twenty-four years of its existence. It might, however, have effected much more good and extended its influence more widely if all the duplicate specimens had been made up into sets and distributed soon after they were collected. But this was impossible with the limited means at the command of the Institution and the assistance it could obtain from voluntary unpaid collaborators. Besides this, some advantages have resulted to science from the retention in the Institution of a large number of every variety of a class of specimens. This has enabled the naturalist to make comparisons which would have been otherwise impossible, to mark peculiarities connected with age, sex, food, climate, etc., and to observe the diversities of form and structure due to the varying conditions of life. As an illustration of this remark we may refer to the results which Professor Baird has been enabled to arrive at from the unrivalled opportunity which he has had in the extensive collection of the Institution, of

studying the relations of nearly sixty thousand specimens of the birds of North America.

The object of the collection we have just described is exclusively the advance of science. The specimens require comparatively but little space for use and preservation. Not being intended for public exhibition they need not be mounted, but may be kept in drawers, or packed away in labeled boxes or casks until wanted for a special investigation.

Another class of large museums are of a mixed character, combining in their object scientific investigation with special systematic and collegiate instruction. Of this class is the great museum at Cambridge, supported principally by the State of Massachusetts, and under the direction of Professor Agassiz. This museum, which may be considered a model of its class, embraces—first, an immense number of original specimens, in the study and description of which a number of accomplished naturalists are continuously employed; second, a series of specimens which have been scientifically described, and so arranged in accordance with their affinities as to enable the student in any branch of natural history to obtain, with the least expenditure of labor, a definite knowledge of what is known of the objects to which he is devoting his attention; third, a series of specimens of genera so arranged as to serve as illustrations of the courses of lectures to the students of the university on such general principles of natural history as form an essential part of a liberal education. This museum, therefore, affords ample means for the advancement of science by original investigation; for the special training of students who desire to devote themselves to natural history, and for collegiate instruction, while the facilities which it is calculated to afford in these lines are only limited by the funds which it can command.

Another class of museums supported at the public expense are those intended almost exclusively for popular instruction and amusement. Museums of this class have been established in several of the principal cities of Great Britain, and I doubt not that the beneficial effects they are producing will induce other cities to follow their example. The most important of these is the one at Liverpool, in which series of generic specimens are admirably mounted and so arranged as to clearly exhibit their relations and affinities. They are, moreover, all distinctly labeled, so that the visitor, almost without an effort, receives definite impressions, valuable in themselves, and which, by association of ideas, become more important as centers around which other ideas, derived from future reading and observation, may be clustered. The impressions made through the eye are not only the most definite, but also the most indelible. Museums of this kind ought to be established at the public expense in every city or community which can afford the means for their support. So popular are collections of objects of natural history and ethnology, that large establishments of mere heterogeneous materials are frequently sources of profit to those to whom they belong.

In some cases, in a better class of museums, a small admission fee is demanded, and the whole proceeds of this expended in sustaining and enlarging the collections. As an example of this I may mention the public museum established by Mr. Woodward in San Francisco, which is not only a source of continued amusement to the inhabitants of that city, but also a means of adult education, since the specimens are generally well classified and properly labeled. Advantage should be taken through museums, of a feature of the human mind essential to progress, the desire for novelty, to lead the public to the employment of the intellectual pleasure derived from the study and contemplation of nature. It is truly surprising how tastes may be formed, how objects before disregarded may, when viewed as a part of a natural family, be invested with attractions which shall ever after render them sources of refined pleasure and unalloyed enjoyment.

While the Smithsonian Institution should continue to devote a portion of its own funds to assist in explorations which have for their object the advance of science, the public museum, with the care of which it is intrusted by Congress, should, in my opinion, without detracting from its scientific character, largely partake of the popular element. It is to be supported by the Treasury of the United States, and should, therefore, be an object of interest to the large number of visitors who are annually drawn to Washington by curiosity or otherwise, and who cherish a patriotic pride in whatever redounds to the reputation of the national capital.

Besides specimens properly labeled for study, especially of the continent of North America, it should contain those to fully illustrate in part, at least, the more prominent divisions of the animal, vegetable, and mineral kingdoms. These should be so arranged, regard being had to artistic effect, as to exhibit the principles of classification, the relation of organs to one another and to those of their allies, the phases of their organization, and other peculiarities relating to their habits and places in the economy of nature. To assist in this, models and pictorial illustrations of magnified smaller parts and of minute structures should be supplied. In every instance the objects should be accompanied with copious legible descriptions, and in no case should a group contain a single specimen more than is absolutely necessary for the general purpose. Economy of space in a public museum should never be consulted at the expense of clearness of illustration. The national museum should contain skeletons in the original, or casts in plaster, of all the larger fossil animals—sections and scenic representations on a large scale of geological periods, and modeled figures of the different races of men and species of animals.

The space which is at present available in the Smithsonian building for a general public museum consists of the following apartments:

1. On the first floor a room 200 feet long and 50 feet wide. 2. Another large room, in the west wing, 65½ feet long by 35 feet wide, with a

semi-circular projection at one end. 3. A connecting range of 60 feet long by 37 wide. 4. In the second story a single large room of 200 feet long and 50 feet wide. The large room on the first floor is not well adapted to the display of specimens, since it is occupied through its whole length with two rows of colossal columns. The upper room, however, as well as that in the west wing of the building, is entirely free from all hindrance to an arrangement with a view to the best exhibition of the collections. I have said that the rooms above mentioned constitute the present available space for the accommodation of the museum. When, however, more space is required, the eastern wing, now in part occupied as a residence by the Secretary, can be employed for the purpose. The floor and partitions which separate the several apartments of this portion of the building are of a temporary character and can be readily removed. The lower part of this wing and its basement are now used for containing the exchanges and as store-rooms for duplicate specimens of geology and mineralogy. In accordance with the views which have been presented, it is intended to devote the whole of the large room in the second story of the main building to archæological objects with skeletons, life-size drawings, and restorations of the larger mammals contemporary with primitive man, especially on the continent of America. Second, to appropriate the wall-surface and a part of the floor-space of the western wing of the building to mineralogy and geology. The portions of the extensive walls of this room can be covered on the east side, which presents an unbroken surface above the top of the cases of 65 feet by 10 feet, with a geological section across the continent, and the opposite wall with drawings of the characteristic fossils of the strata which are exhibited on the eastern wall. The side and mineral cases for containing the specimens, besides exhibiting a characteristic series of specimens, to represent general geology, mineralogy, and palæontology, will be occupied with full sets of specimens to illustrate the geological formation of North America, and especially the mineralogical resources of this country.

The collection of objects to illustrate anthropology now in possession of the Institution is almost unsurpassed, especially in those which relate to the present Indians and the more ancient inhabitants of the American continent. An artistic and scientific exhibition of these in the large room we have mentioned, could not fail to be highly interesting to the general public, the student of ethnology, and especially to the many intelligent foreigners who visit the capital of the United States. There are also in the collection of specimens in charge of the Institution full sets of all the rocks and minerals collected by the several exploring expeditions which have been sent out by the General Government, besides those which have been presented as free gifts or in exchange to the Institution from all parts of our continent. We can, therefore, with scarcely any additional material, or only with such as can be readily obtained, render the national museum much more

creditable to the Government and the Institution than it has ever yet been. Such a collection will tend to draw to itself numerous isolated collections, especially of anthropology, which, though they may be of much interest to the individuals possessing them, are of comparatively little value in the way of advancing a knowledge of the subject to which they pertain, and, in case of the death of the owners, are generally dissipated and frequently lost to the world. The only way in which they can become of real importance is by making them part of a general collection, carefully preserved in some public institution, where they can be studied and compared with other specimens, and where, in the course of the increasing light of science, they may be made to reveal truths beyond present anticipation.

Herbarium.—An account of the transfer of the extensive collection of plants of the Institution to the care of the Department of Agriculture has been given in previous reports, but it is thought important to place on record a more detailed history of this collection than has yet been published, and I therefore present the following account of it from notes furnished by Dr. Torrey.

The Institution having accumulated a large number of botanical specimens collected in various parts of the world, most of them brought home by the Government exploring expeditions, others presented by authors of botanical works, travelers or special collectors, the offer was made by Professor John Torrey to arrange, without compensation, all these separate collections into one general herbarium. This offer was gladly accepted on the part of the Institution, and all the specimens on hand, and all that were subsequently received up to 1869, were transferred to him. When he commenced the task, the specimens, especially those collected by the Institution, were still in bundles as they were received, and all required to be poisoned to prevent their destruction by insects, which had already commenced their ravages. The plan adopted by Dr. Torrey for the arrangement of the plants was of the most approved character. Each species, often represented by several specimens, and all the marked varieties, are fastened to a half sheet of strong white paper and labeled. All the species of a *genus* are laid on one or more whole sheets of thicker tinted paper, on the lower left-hand corner of which the generic name is written. The genera are arranged according to the natural system, following for the most part the order of De Candolle. A very large proportion of the specimens are authentically named by the authors who have described them; and as they are the type-specimens or originals of several important works are invaluable for reference. Some of the more valuable portions of the Smithsonian herbarium are the following:

1. The plants collected by the exploring expedition under the command of Admiral Wilkes, during the years 1838 to 1842. Many countries were visited in this voyage round the world, and an extensive herbarium

brought home. The botanists of the expedition were Mr. William Rich, Dr. Charles Pickering, and Mr. W. I. D. Brackenridge. To the last-named gentleman was assigned the description of the ferns, his report on which was printed by order of Congress in a handsome quarto volume, with a folio atlas, containing beautifully engraved figures of the new or little-known species. After a very few copies of this work were distributed, the remainder of the edition was destroyed by fire while in the hands of the binder. The copper-plates, however, are still in the custody of the Library Committee of Congress, and it would cost but little to print a new edition of a work so much desired by a large number of botanists. The flowering plants, with the exception of those collected in California and Oregon, were referred to Dr. Torrey; others were partially studied by Mr. Rich, and then committed to Professor Asa Gray for a more thorough investigation. Of this portion of the collection only one quarto volume of text, and a large folio volume of illustrations, have thus far been published by Congress. For a number of years the publication of the works relating to the exploring expedition was in charge of the Joint Library Committee of Congress and Admiral Wilkes, but it was impossible to procure appropriations to defray the large expense of the undertaking. At length all the materials were transferred to the Smithsonian Institution, provided it would publish for distribution an edition of the whole. The limited income of the Smithsonian fund did not permit the Institution to embark in so formidable an undertaking, and plates, manuscripts, and printed matter are still in possession of the Committee on the Library of Congress.

Professor Gray is ready to go on with his work as soon as provision is made for its publication. Dr. Torrey's report has been long since completed, and the illustrations drawn, engraved, and even printed. At this late day, however, the report would require revision; indeed, so many new and rare species described in it have since been found and described by other botanists, that it may be sufficient to publish a very brief report, accompanied by the plates alluded to above. The *Mosses* were described and beautifully illustrated by W. S. Sullivant, esq., of Columbus, Ohio. The text in quarto of his valuable report is also printed, but not published. He has, however, at his own expense, printed for private distribution a beautiful edition of it in folio. The *Algæ* were committed to Professor J. W. Bailey, of West Point, and Professor W. H. Harvey, of Trinity College, Dublin, whose report on these plants, with elaborate illustrations, is printed, and has been, for years, stored away in sheets awaiting to be bound up and published with Dr. Torrey's report. The same may be said of Professor Tuckerman's account of the *Lichens*, and of the reports by Rev. M. A. Curtis, of North Carolina, and Rev. Dr. Berkely, of England, on the *Fungi*.

2. The next most extensive and valuable portion of the herbarium is the collection of plants made during the North Pacific exploring expedition, under command of Commanders Ringgold and Rodgers, from 1853

to 1856, by Mr. Charles Wright, an accomplished botanist, who accompanied the Mexican boundary commissioners in their surveys, and who has also made extensive botanical explorations in Cuba. There has been no full report of the collections made on the North Pacific expedition, though many of the new species have been published by Dr. Gray.

3. The naturalists who accompanied most of the surveying parties which made explorations for the route of a Pacific Railroad collected large numbers of plants, many of which were new to the botanist, and have been described in the published reports of these explorations.

4. Collections made in the Mexican boundary survey by Dr. C. C. Parry, Dr. J. M. Bigelow, Mr. C. Wright, Professor George Thurber, and Mr. Arthur Schott, are among the most extensive and valuable portions of the herbarium. A full account of them, by Drs. Gray, Engelmann, and Torrey, is contained in General Emory's report. The Cactaceæ, and one or two smaller orders, were described by Dr. Engelmann; the Compositæ, Scrophulariaceæ, and one or two other orders, by Dr. Gray; and the ferns, with their allies, by Professor D. C. Eaton. The remaining Cryptogamia are not included in the report, but most of the new or rare ones have been published elsewhere. The grasses were to be described in a separate memoir by Professor Thurber.

5. Large additions have been made to the North American portion of the herbarium, chiefly from within the limits of the United States and Territories, by contributions from the following places: New England, by Mr. Oakes, Dr. Gray, Professor Tuckerman, S. T. Olney, esq., Professor D. C. Eaton, and others; New Jersey, by Mr. C. F. Austin, Professor Eaton, Dr. Torrey, and Dr. Knieskern; New York, Messrs. Austin, LeRoy, Clinton, Torrey, and many others; Pennsylvania, by Dr. Darlington, and Professor Thos. C. Porter; North Carolina, by Rev. Dr. Curtis; Florida, by Dr. Chapman, (type-specimens of his flora of the Southern States;) Alabama, by Professor Winchell; Kentucky, Dr. Short, and Mr. Sullivant; Texas and New Mexico, Messrs. Fendler, Ervendberg, and others, besides what the botanists collected in the Mexican boundary survey; Rocky Mountains, Dr. Parry, Captain Macomb, and Dr. Newberry; Oregon, Mr. Geo. Gibbs, and others; Nebraska, Dr. Hayden; Nevada, Mr. Stretch; California, Dr. H. M. Bolander, General Frémont, Miss Davies, Th. Bridges, Mr. E. Samuels, Dr. Torrey, and many others; Colorado, Dr. Anderson, Frémont, and others. Besides these principal sources of United States plants, very many specimens have been received from other places and persons, which we have not space to enumerate. From British America, especially the sub-arctic portions, Dr. Kennicott, and officers of the Hudson's Bay Company have furnished specimens. Of foreign plants, besides those collected in the two United States exploring expeditions already noticed, the herbarium contains valuable and large contributions from Japan, Mantchuria, China, etc., from Professors Reïgel and Maximovitch, of the Imperial Academy of Science of St. Petersburg, and the Imperial Botanic Garden: A

large collection of Sandwich Island plants, (all type-specimens,) made by Mr. Horace Mann, lately deceased: A collection of plants from Mirador, Mexico, by Dr. Sartorius: Many specimens, with fleshy fruits in alcohol, collected on the Panama Railroad, by the late Dr. Sutton Hayes; others from the same region by Fendler, in 1850: Plants from Jamaica, especially ferns from Mr. Wilson; from Cuba, collected by Mr. Chas. Wright; Venezuela, many beautifully dried ferns by Fendler; from Texas and Northern Mexico, by Berlandier; Lower California, by Mr. Xantus; Brazil and Paraguay, by unknown collector. From Europe, there is an extensive collection of Hungarian plants from Mr. Arthur Schott, and of Illyrian plants from Professor Thomasini, besides many smaller collections from various parts of the continent. Dr. Torrey has contributed a large number of specimens from his own herbarium.

As to the disposition made of the duplicates of the collections, they have been sent in the name of the Smithsonian Institution to learned societies, botanic gardens, and individuals, whenever they could be disposed of for the advance of science. Full sets of duplicates were presented to the Royal Garden at Kew, near London, the botanic gardens of Paris and St. Petersburg, besides smaller portions to individuals, lyceums of natural history, and colleges.

This collection of plants has been transferred to the Agricultural Department, on the conditions set forth in the following documents, of which the originals are in the archives of the Institution and of the Agricultural Department:

WASHINGTON, D. C., *January* 1, 1868.

In order to the harmonious co-operation of the Smithsonian Institution and the Department of Agriculture in their respective provinces of advancing science, they enter into the following agreement relative to the disposition of specimens:

First. All the botanical specimens in possession of the Smithsonian Institution, about twenty thousand, and all that may hereafter be collected by it, shall be transferred to the Agricultural Department on the following terms:

1. That a competent botanist, approved by the Institution, shall be appointed to have charge of the collection.

2. That the collection shall, at all times, be accessible to the public for educational purposes, and to the Institution for scientific investigation, or for supplying any information in regard to plants that its correspondents may ask for.

3. That due credit be given to the Institution in the report of the Agricultural Department for the original deposit, and for such additions as may be made to it, from time to time, by the Institution.

Second. That the Agricultural Department shall transfer to the Smithsonian Institution any specimens it may now have, or may hereafter obtain, that are not necessary to illustrate agricultural economy; such as

those of ethnology and of various branches of natural history. Similar credit to be given in this case as is required in the former.

HORACE CAPRON,
Commissioner of Agriculture.
JOSEPH HENRY,
Secretary of the Smithsonian Institution.

The following is an account of the more important additions which have been made to the collection in the Agricultural Department by the Institution since the transfer of the general herbarium in 1868:

1. A set of European plants, numbering about four hundred species, presented by Professor Paul Reintz, of Germany, in exchange, at his request, for specimens of American plants.

2. A second very extensive collection of plants from the Imperial Academy of St. Petersburg, in return for donations from the Institution. This present, like all of those we have received from the Imperial Academy, is of a most valuable character. It consists of eleven hundred species from Russia, Siberia, Western Europe, and Japan.

3. Another large collection is from the widow of the late Mr. James McMinn, Williamsport, Pennsylvania, principally of plants from the mountainous regions of Pennsylvania, but also comprising specimens from other parts of this country and different localities in Europe. Mr. McMinn was a civil engineer, and in the practice of his profession in surveying lines for railways and canals became interested in the variety of plants which were presented to his notice, and as a means of recreation, as well as of intellectual improvement, commenced the study of botany. It would appear from the examination of his herbarium, that he had entered into extensive correspondence with some of the principal botanists of this country and Europe, and had enriched his collection by exchanges. His herbarium contained about five thousand species, among which is an interesting series of plants from the Alps. The special thanks of the Institution are due to Mrs. McMinn for the judicious disposition she has made of the results of the labors of her lamented husband, which we trust will be preserved among the collections of the Government, as a permanent memorial of his devotion to science and of her enlightened liberality.

Besides the foregoing there have been added several hundred bottles of samples of agricultural materials and products, numerous specimens of seeds, roots, fibers, fungi, sections of wood, &c.

Work done in connection with the collections.—Professor Baird, during the past year, in addition to his services in regard to the exchanges, natural history, and assistance in correspondence, has completed the systematic description of the land birds of the Pacific States, forming the first volume of ornithology published, in connection with its geological survey, by the State of California. The materials for this work

were from the manuscript notes of Dr. J. G. Cooper, of San Francisco, while the descriptions are principally from specimens in the Smithsonian collections. This volume, in regard to its typography, illustrations, and the character of its contents, does honor to the liberality of the State at whose expense it was published, as well as to the science of the country. Professor Baird has also continued his labors with Dr. Brewer, of Boston, on a work relative to the general ornithology of North America; in this he has been assisted by Mr. Robert Ridgeway, the zoölogist of the exploration of the fortieth parallel under Clarence King. To the latter, free access has also been given, in the preparation of his report on the birds of Mr. King's survey, to all the ornithological specimens in the Smithsonian collections.

Mr. Meek, the palæontologist, has made a preliminary report on the fossils collected by Dr. Hayden in his survey of Wyoming and contiguous Territories, and prepared lists of the same, with descriptions of the new species. He has described and prepared drawings of a collection of cretaceous fossils, sent by Professor Mudge to the Institution, from Kansas. He has made, besides several preliminary examinations, a final report on the fossils collected by Mr. King in the survey of the fortieth parallel, with full descriptions and illustrations of all the new species. He has also investigated the invertebrate fossils collected by the geological survey of Ohio, and prepared descriptions of the new species for publication; made a preliminary report, with descriptions of some new species, on a collection of carboniferous fossils sent by Professor Stevenson from West Virginia; continued his work on the illustrations of the monograph of the palæontology of the Upper Missouri. He has also identified collections of fossils, received from time to time at the Smithsonian Institution from collectors in various parts of the country.

Mr. Dall has been engaged in collating the extensive collection of manuscript notes of the Hudson's Bay and other Arctic American collaborators with whom the institution has been in correspondence for more than fifteen years. The part of these notes which he has finished relates to ornithology, and comprises many thousand items descriptive of the habits, distribution, and numbers of the birds of the regions above referred to. These will be used by Professor Baird and Dr. Brewer in their work on the birds of North America. The manuscripts also contain notes relative to the mammals and other animals, as well as to the ethnology of the same regions. When all these are collated and published they will form an interesting contribution to existing knowledge of the natural productions and ethnology of the North American continent.

Mr. Dall has also devoted considerable time to original investigations relative to the minute anatomy of the mollusca from specimens in the collections of the Institution. His principal labor, however, has been in the rearrangement of the very large series of shells from the west coast of America and of the North Pacific, including many types of the new

species of Gould, Carpenter, Cooper, Stearns, Pease, H. and A. Adams, &c. These have mostly passed through the hands of Dr. P. P. Carpenter, of Montreal, but still required to be placed in suitable trays, and provided with new labels and specially arranged for cabinet purposes. He has also had charge throughout most of the year of the record of additions to the museum, and the labeling of collections, especially those of ethnology and osteology.

Meteorology.—The system of meteorology of the Institution has been kept up as usual during the past year. The number of observers reporting to the Institution during this period is 515, and to the Medical Department of the United States Army, to the records of which we have free access, 140. The value of these observations increases with the number of observers and the time for which the several series are continued. But observations, however long-continued and extensive, are comparatively of little value unless they are reduced and discussed; and these operations can only be performed at the expense of great labor, since thousands of figures have to be tabulated and subjected to various arithmetical processes in order to deduce the general results which constitute approximate scientific principles. As we have stated in previous reports, the discussion of the rain and temperature has been for some years in charge of Mr. Charles A. Schott. The results in regard to the rain have been printed, and will form a part of the Smithsonian Contributions for the year 1871. A general account of these results was given in the last report, but in this it may be further stated that the principal deductions are made from an original series of tables giving the monthly rain-fall from the earliest periods from all sources in the United States and adjacent countries down to 1867. From these general tables a series of consolidated tables of means for seasons and years, for the whole time, is deduced. It was thought advisable, on account of the great expense, to publish for the present the consolidated tables, and to retain the others for reference or to answer special inquiries in regard to the rain-fall of particular stations. The former have been kept up to date, all the new materials having been incorporated; and to extend the system a large number of rain-gauges have been distributed to different parts of the country, and especially to the western States.

The temperature records are still under investigation by Mr. Schott. The work was in part temporarily suspended during his absence in Europe as a member of the expedition for observing the total eclipse of last December. The following is a statement of the present condition of the discussion.

The collection of material has for the most part been completed down to the present time, and tables of hourly, bi-hourly, and semi-hourly observations of temperature have been prepared. From these have been deduced tables to be used for the correction of daily variations of temperature. The daily fluctuation of the atmospheric temperature

has been discussed, and tables giving the times of sunrise and sunset for stations between latitudes 23° and 60°, to be used for corrections of daily variation, have been computed. The annual fluctuations of temperature have been in part discussed, and the tables of maxima and minima are in an advanced state toward completion.

All the observations relative to the winds, made under the direction of the Institution, and under the Medical Department of the Army, and all those which have been collected from other sources, have been placed in charge of Professor J. H. Coffin, of Lafayette College, for reduction and discussion. It was first intended to limit the investigation to the winds of North America, but it has since been considered advisable to incorporate the whole in a memoir on the general direction of the winds of the globe. To defray the cost of the extra labor, other than that of Professor Coffin, in this investigation, an appropriation has been made from the income of the Institution. During the year, Professor Coffin has been pressing on this work, with a number of assistants, as rapidly as the means at his command and his time would allow.

The Smithsonian meteorological system was commenced in 1849, and has continued in operation until the present time. Its efforts have been directed in the line of supplementing and harmonizing other systems, of a more limited character, with that of the more general one of the Army of the United States, and in some measure with the system established in Canada. It has done good service to the cause of meteorology, 1, in inaugurating the system which has been in operation upward of twenty years; 2, in the introduction of improved instruments after discussion and experiments; 3, in preparing and publishing at its expense an extensive series of meteorological tables; 4, in reducing and discussing the meteorological material which could be obtained from all the records from the first settlement of the country till within a few years; 5, in being the first to show the practicability of telegraphic weather signals; 6, in publishing records and discussions made at its own expense, of the Arctic expeditions of Kane, Hayes, and McClintock; 7, in discussing and publishing a number of series of special records embracing periods of from twenty to fifty years in different sections of the United States, of great interest in determining secular changes of the climate; 8, in the publication of a series of memoirs on various meteorological phenomena, embracing observations and discussions of storms, tornadoes, meteors, auroras, &c.; 9, in a diffusion of a knowledge of meteorology through its extensive unpublished correspondence and its printed circulars. It has done all in this line which its limited means would permit, and has urged upon Congress the establishment, with adequate appropriation of funds, of a meteorological department under one comprehensive plan, in which the records should be sent to a central depot for reduction, discussion, and final publication.

An important step has been made toward this desirable object in the

establishment, during the last year, by Congress, of a system of practical weather reports under the direction of the War Department, with ample means for the purchase standard instruments, the pay of assistants, and telegraphic dispatches. The results of this system in the way of prediction have been eminently successful, and have everywhere met with popular favor. The organization and administration of the system by General Myer, the director, has evinced great executive ability, and his wisdom has been shown in selecting Professor Abbe as his scientific assistant. It should be recollected, however, that the principles employed in foretelling the weather are practical results previously arrived at by the investigations of men of abstract science founded on simultaneous records without the aid of telegraphic communication. For the discovery of the general laws of meteorological phenomena, simultaneous observations should be made over large portions of the earth, and the records of these collected at stated periods, say at the end of every month, at some central office, and submitted first to preliminary reduction, and finally to the critical study of men like Espy, Redfield, and others, fitted by education, experience, and mental peculiarities to deduce from them the required generalizations. I would therefore suggest that a still larger appropriation be made by Congress to the War Department for establishing, besides the reports for weather signals, a series of intermediate stations, also furnished with compared instruments, to record daily observations to be transmitted to Washington weekly or monthly, and also that provision be made for the support of a number of competent persons to carry on the reductions and prepare the results for publication.

It has been the policy of this Institution from the first to do nothing which can be done as well or better by other means, and in accordance with this policy the Institution would willingly relinquish the field of meteorology, which it has so long endeavored, though imperfectly, to cultivate, turning over to the Signal Office all the material which it has accumulated up to a given epoch. We would advise also a similar course to be pursued on the part of the Medical Department of the Army. All the deductions from the combined materials which have been collected up to the present time should be obtained and published, although since, they may be in many respects defective, they contain the essential element of long periods of meteorological changes and a new era commence with more precise instruments and improved methods of observation. From such a system, however perfect it may be, immediate results are not to be expected. New and important deductions can scarcely be obtained until after a continuance of the system for several years, as, for example, the accurate determination of the periodicity which probably exists in regard to the droughts of the western coast.

Before closing this report it is proper that I should refer to a resolution adopted by your honorable board at its last session, granting me leave of absence to visit Europe to confer with savans and societies relative to the Institution, and making provision for the payment of my expenses. The presentation of this proposition was entirely without my knowledge, but I need scarcely say that its unanimous adoption was highly gratifying to my feelings, and that I availed myself of the privilege it offered with a grateful appreciation of the kindness intended.

I sailed from New York on the 1st of June, returning, after an absence of four and a half months, much improved in health and with impressions, as to science and education in the Old World, which may be of value in directing the affairs of the Institution. Although limited as to time, and my plans interfered with somewhat by the war, I visited England, Ireland, Scotland, Belgium, parts of Germany and France. But deferring, for the present, an account of my travels and the observations connected with them, I will merely state that, as your representative, I was everywhere kindly received, and highly gratified with the commendations bestowed on the character and operations of the Institution intrusted to your care.

Respectfully submitted.

JOSEPH HENRY.

JANUARY, 1871.

APPENDIX TO THE REPORT OF THE SECRETARY.

Table showing the entries in the record-books of the Smithsonian Museum in 1869 and 1870.

Class.	1869.	1870.
Skeletons and skulls	9,708	11,512
Mammals	9,516	9,773
Birds	58,976	61,150
Reptiles	7,517	7,535
Fishes	7,885	7,897
Eggs of birds	15,500	15,671
Crustaceans	1,287	1,287
Mollusks	21,770	22,345
Radiates	2,725	2,730
Annelids	100	100
Fossils	7,283	7,380
Minerals	6,977	7,154
Ethnological specimens	9,233	10,000
Plants	175	175
Total	158,652	164,709

Total entries during the year 6,057

Of the above enumeration, 4,154 specimens of the birds and 500 of the mammals are mounted and on exhibition in the hall.

Approximate table of distribution of duplicate specimens to the end of 1870.

Class.	Distribution to the end of 1869.		Distribution in 1870.		Total.	
	Species.	Specimens.	Species.	Specimens.	Species.	Specimens.
Skeletons and skulls	154	593	60	78	214	671
Mammals	885	1,706	31	76	916	1,782
Birds	12,951	18,996	2,200	3,564	34,951	22,530
Reptiles	1,701	2,830	40	40	1,741	2,870
Fishes	2,434	5,210	1	1	2,435	5,211
Eggs of birds	4,381	11,711	2,074	4,683	6,455	16,394
Shells	78,391	177,927	3,087	5,230	81,178	183,157
Radiates	551	727	32	51	583	778
Crustaceans	1,023	2,526	55	124	1,078	2,650
Marine invertebrates	1,838	5,152	....	....	1,838	5,152
Plants and packages of seeds	13,658	19,218	1,845	1,845	15,503	21,063
Fossils	3,958	9,984	....	....	3,958	9,984
Minerals and rocks	2,880	7,774	750	800	3,630	8,574
Ethnological specimens	1,107	1,154	36	36	1,143	1,190
Insects	1,532	2,846	100	100	1,632	2,946
Diatomaceous earths	26	566	2	2	28	568
Total	127,470	268,920	10,313	16,630	127,783	285,520

ADDITIONS TO THE COLLECTIONS OF THE SMITHSONIAN INSTITUTION IN 1870.

Adams, F. C.—Limestone rock, Virginia.

Agricultural Department United States, Hon. Horace Capron, Commissioner.—Skin of monkey and parrot, South America; reptiles in alcohol, from Colorado, California, and the East Indies; dry fish and crustacea from China and New York Harbor. (See elsewhere under other entries.)

Aiken, E. C.—Skins of *Leucosticte tephrocotis*, Rocky Mountains.

Albuquerque, Don Frederico.—Barrel of fish in alcohol, from Brazilian rivers.

Alden, Dr. C. H., United States Army, through the Army Medical Museum.—Petrified wood, fossils and minerals, from Colorado Territory.

Anderson, General, through J. M. Thompson.—Fresh heads, hoofs and skins of the American bison, Kansas.

Army Medical Museum, United States; Dr. George A. Otis, United States Army, in charge.—Stone implements from Colorado Territory; fossil teeth of mastodon, &c., Alabama. (See also under the names of the medical officers United States Army.)

Baird, Professor S. F.—Carvings of northeastern Eskimo; arrow-heads, relics from ancient shell-heaps on the coast of Massachusetts; fish and turtles in alcohol, fin of thresher shark, jaws and skeletons of fish, from Wood's Hole, Massachusetts.

Bannister, H. M.—Arrow-heads, &c., Illinois.

Baurmeister, Rev. W.—Minerals, Indiana.

Balbach, A.—Fœtal mice in alcohol, New Jersey.

Baldwin, Charles S.—Archæological specimens, Tennessee.

Barker, T. S.—Shell adze and arrow-heads, Florida.

Bentley, Dr. E., Assistant Surgeon United States Army, through Army Medical Museum.—Stone implements, San Francisco Bay, California.

Berendt, Dr.—Turtles, fossil fish and plants, from Mexico.

Berthoud, Captain E. L.—Flint-flakes and scrapers, Colorado Territory.

Bishop, N. H.—Cuban mocking-birds in alcohol.

Blackmore, William.—Model of Stonehenge and flint implements, Great Britain.

Boardman, George A.—Bird skins, nests, and eggs, from Maine and Florida; models of great auk egg, skulls of buffalo and gnu, South Africa.

Bolander, Dr. H.—Californian seeds.

Boucard, A.—Bird skins from Mexico.

Bowman, J. B.—Collection of birds, and one mammal, from Australia.

Brevoort, J. Carson.—Bones of the dodo, from Mauritius.

Brown, Solomon G.—Arrow-heads, District of Columbia.

Bryan, O. N.—Pottery, stone implements, arrow-heads, &c., Virginia.

Bryant, Captain Charles.—Skins of the walrus and seal, from Alaska.

Burn, J. P.—Specimens of rock from the Bosphorus.

Burr, Fearing—Specimens from Massachusetts shell-heaps.

Burrough, J.—Nest and skin of mourning warbler, New York.

Cameron, John.—Mask from an Egyptian sarcophagus.

Central Park Commissioners, New York.—Cast of antique statue, Costa Rica.

Chase, Thomas.—Stone mortar and pestle, Virginia.

Coleman, N.—Insects from Ohio.

Collins, H.—Specimens from shell-heaps, Louisiana.

Condon, Rev. Thomas.—Fossils from Columbia River.

Cooper, Theodore.—Shells from the Galapagos Islands.

Coues, Dr. Elliott, United States Army.—Bird-skins from North Carolina.

Curtis, Dr. Josiah.—Indian implements, pottery, &c., from Tennessee and Georgia.

Dall, Rev. C. H. A.—Skull and horns of the buffalo of southern India.

Dall, W. H.—Specimens of mollusca and shells from various localities.

Damon, R.—Specimens of brachiopods from the European seas.

Dant, Thomas E.—Abnormal eggs of domestic fowl.

Davis, Henry.—Fossils from Iowa.

Day, Robert, jr.—Stone implements from Ireland.

Domeyko, Professor, University of Chili.—Chilian minerals.

Dow, Captain J. M.—Skulls and bones of tapirs from Central America; young tapir in alcohol, and other alcoholic specimens, from Panama.

Durkee, H. R.—Human remains and fossils from Wyoming Territory; birds, eggs, and nests, with some osteological specimens, from the same locality.

Evans, Abner G., by the Hon. W. Townsend.—Stone implements from Pennsylvania.

Finck, Hugo.—Stone antiquities from Mexico.

Fitzgerald, Dr. J. A., United States Army, (by Dr. J. S. Billings, United States Army.)—Fossil teeth from Indian Territory.

Flügel, Dr. Felix.—Alcoholic specimens, Europe.

Foreman, Dr. E.—Fresh-water shells, District of Columbia.

Gardner, G. T.—Specimens from Maine shell heaps.

Gibbs, Mr.—Box seeds, nuts, &c., Kansas.

Girard, Dr. Basil, United States Army, (through Army Medical Museum.)—Fossils from Wyoming Territory.

Gleason, W. T.—Glaciated rock, Connecticut.

Glover, Lieutenant Russell, United States Revenue Marine.—Specimens of *Acmæa testudinalis* and *Boltenia clavata* from the coast of Maine.

Graves, E. D.—Lignite, Pennsylvania.

Graves, W. W.—Infusorial earth from Maine.

Guest, Follis, (through Hon. W. Townsend.)—Stone implements, Pennsylvania.

Hachenburg, Dr.—Scale of sturgeon.

Hall, George E.—Specimens of grinding and building stone, Ohio.

Hall, John.—Indian crania and bones, San Francisco.

Haney, Jesse H.—Indian silver ornament, Arkansas.

Hansen, Walter.—Stone awl, Missouri. Apache basket from New Mexico.

Hartman, Dr.—Collection of insects, Pennsylvania.

Haskins, Mr.—Horned toad, California.

Hayden, Dr. F. V.—Beaver cuttings from the Rocky Mountains. (See also United States Geological Survey of Territory.

Heaton, L. D., (through Agricultural Department.)—Reptile from Texas.

Henriques, Captain United States Revenue Marine.—Ethnological and botanical collections from Alaska.

Himes, Professor C. F.—Bones from the Carlisle bone-cave, Pennsylvania.

Hinckley, J. R.—Fish and fishbones, Massachusetts coast.

Hoover, H.—Fossils and arrow-heads, Pennsylvania.

Hoxie, Walter.—Eggs of *Cathartes atratus*, South Carolina.

Hoy, Dr. P. R.—Fish, &c., from deep dredgings off Racine, Wisconsin.

Hutchinson, Kohl & Co.—Seal-skins, walrus skull and volcanic sand, Alaska.

Jackson, Haliday, (through Hon. W. Townsend.)—Stone implements, Pennsylvania.

Jackson, R. S.—Osteological and oölogical specimens from Louisiana.

Johnson, Eugene.—Indian redstone pipe.

Johnson, Lieutenant.—Specimen of an owl, District of Columbia.

Jones, Rev. C. M.—Nests of *Ammodromus maritimus* and *candacutus*, Connecticut.

Jones, Jno. P.—Cranium of mound builder, Missouri.

Jones, Strachan, Hudson Bay Company.—Collection of birds and eggs, Little Slave Lake, Hudson Bay territory.

Keenan, T. J. R.—Unionidæ, specimens of ethnology and natural history from Mississippi. Two specimens of continental currency.

Kellogg, Dr. A.—Plants from California.

King, Clarence.—Stone pestle, California. Minerals and rocks from Nevada.

Knapp, Dr. James.—Collection of fossils, Kentucky.

Knight, Jeremiah.—Plate of crystallized quartz from Orange County, New York.

Kohler, Mr.—Seventy pound mass of silicate of zinc, Union Lead Works, Virginia.

Lancaster, Dr.—Mineral residue from water of Alum Springs, Virginia.

Lartet, Professor E.—Bone breccia from the bone-caves of Dordogne, France.

Latham, General G. R.—Skin of kangaroo, Australia.

Latimer, George.—Collection of birds, Porto Rico.

Laming, Dr. F.—Stone implements, Indiana.

Lewis, Dr. James—Fresh-water shells, Mohawk River, New York.

Limpert, W. R.—Nests and eggs, Ohio.

Lincecum, Dr. G.—Alcoholic mammals and reptiles, Mexico.

Linden, Charles.—Three bird-skins, New York.

Lockhart, James, Hudson Bay Company.—Birds and eggs, Fort Yukon, Alaska.

Long, Owen, M., United States Consul.—Fish from Panama.

Luddington, Colonel United States Army.—Carvings from the Old Pecos Church, New Mexico.

Lupton, Professor N. T.—Indian stone relics, Warrior River, Alabama.

McElderry, Dr. H., United States Army, (through the Army Medical Museum.)—Fossils from Texas.

Macfarlane, R., Hudson Bay Company.—Birds and eggs from the Anderson River, Hudson Bay territory, being the collections for 1866.

McIlvaine, J. A.—Indian pottery from Pennsylvania.

McIlvaine, J. H.—Birds from Central America.

McLain, R. T., United States Agricultural Department.—Indian stone implements from Maryland.

Madras, Government Museum.—Skeleton of hyena, and collection of East Indian birds.

March, William, (by Agricultural Department.)—Stone knives, Ohio.

Martin H.—Eggs of *Ectopistes migratoria*, from Michigan.

Mathews, Dr. W., United States Army.—Bull-boat used by Indians of the Indian Territory, wooden mortar, matting, head of antelope with deformed horns; ethnological specimens; same locality.

Mechling, Mrs. F. E. D., (through Agricultural Department.)—Reptiles from Belize.

Merritt, E. S.—Indian arrow-heads, Long Island.

Merritt, J. C.—Arrow-heads from Long Island.

Meulen, Lieutenant E. de, United States Army.—Plants from Cook's Inlet, Alaska.

Miller, Dr. George, United States Army.—Bird's eggs, Colorado Territory.

Milne, Edwards, Professor Alphonse.—Casts of *Æpyornis* bones and fossil birds of France.

Minor, Dr. T. T., United States Army.—Indian crania from Vancouver's Island.

Moore, Carlton R.—Fish and corals from the coast of Virginia.

Moore, James H.—Sulphate of strontia, Virginia.

Moore, N. B.—Mounted tree-duck, Louisiana.

Nantucket Athenæum.—Skull of killer whale.

New Albany Society of Natural History.—Cast of a copper spear-head from the mounds, Indiana.

Newman, Jos., (by Agricultural Department.)—Stone implements from South Carolina.

New Zealand Colonial Museum.—Bones of *Dinornis*, and *Apteryx*, shells, bird-skins, and ethnological specimens from New Zealand.

Nickerson, George Y.—Antique soapstone inkstand, Cape Cod.

Northwestern University.—Fossils and skins of gar pike from Illinois.

Orton, Professor James.—Tertiary fossils from the Amazon.

Palmer, Dr. E., (partly through the Agricultural Department.)—Large and varied collections of specimens in various departments of zoölogy, botany, ethnology, and archæology from Arizona, Utah, and New Mexico.

Passmore Lewis, (by the Hon. W. Townsend.)—Stone implements, Pennsylvania.

Pease, Horatio N.—Tooth of fossil cetacean, Gay Head, Massachusetts.

Pim, Geo. E., (by Hon. W. Townsend.)—Stone implements, Pennsylvania.

Platt, L. W.—Indian clothing and ornaments, Nebraska.

Pourtales, L. F. de.—Marine invertebrates from Florida.

Price, J. D.—Crystallized calcite, Virginia.

Quatrefages, Professor.—Casts of osteological and other specimens from the caves of Cromagnon, France.

Rankin, Mr.—Indian crania, Massachusetts coast.

Ransom, Governor, (through Mr. Thos. Bland.)—Land shells from Barbadoes.

Reed, Byron.—*Ortyx Virginianus*, Nebraska.

Ricksecker, L. E.—Birds' eggs, Pennsylvania.

Ridgeway, Robert.—Birds from Illinois.

Ring, Lieut. F. M., United States Army.—Collections of birds, osteological specimens, ethnology, archæology, &c., from Alaska.

Sacho, H.—*Saturnia rubescens* from Chili.

St. Petersburg Imperial Botanic Garden.—Russian, Siberian, Japanese, and other plants.

Salvin, O.—Birds from the Falkland Islands.

Scammon, Capt. C. M., U. S. Revenue Marine.—Baleen of Pacific sulphurbottom whale.

Schott, Dr. A.—Crystals of rock-salt, Texas.

Sclater, Dr. P. L.—Birds from Peruvian Andes and Buenos Ayres.

Sessions, Luther.—Birds' eggs, Connecticut.

Sharpless, P. P., (through Hon. W. Townsend.)—Stone implements from Pennsylvania.

Sherwood, Andrew.—Devonian fish remains from Pennsylvania.

Sibbeston, J., Hudson Bay Company.—Birds and eggs, Fort Yukon, Alaska.

Spinner, General F. E.—Fresh specimen of the copperhead snake, District of Columbia.

Stearns, R. E. C.—Pottery vase and beads from Chiriqui, Central America.

Stelle, J. P.—Archæological and ethnological specimens from Tennessee mounds.

Sternberg, C. H. and Dr. G. M.—Fossil plants from Kansas.

Stevenson, J.—Mounted *Neotoma*, Wyoming Territory.

Stevenson, J. J.—Stone implements, West Virginia.

Stiles, Hon. Jno. D., M. C.—Specimen of iridescent hematite.

Streng, L. H.—Miscellaneous shells.

Stuart, Mrs. R. L.—Stone pipe, Virginia.

Sumichrast, Dr. Francis—Miscellaneous zoölogical collections, Isthmus of Tehuantepec.

Thomas, Ezra, (through Hon. W. Townsend.)—Stone implements, Pennsylvania.

Thompson, R. O.—Fossils and birds' skins from Missouri.

Thomson, J. H.—Eggs of African ostrich, and of *Casuarius Bennettii* or "mooruk" from New Britain, and rocks containing garnets from New Bedford.

Tolman, J. W.—Birds' eggs, Illinois.

Townsend, Hon. W.—Stonei mplements from Pennsylvania. (See also under other entries.)

Turner, G.—Flint implements, Illinois.

United States Geological Survey of the Territories.—Dr. F. V. Hayden in charge. Large miscellaneous zoölogical and paleontological collections from the Rocky Mountains.

Unknown.—Stone ax, Missouri? Stone implements and fossil corals, Canada? Box fossils, Missouri? Skeleton Pottawattomie Indian?

Vickary, Dr. R. S., Assistant Surgeon, United States Army.—Arrowheads and pottery, New Mexico.

Vienna, Imperial Zoölogical Museum of.—Birds and skin and skeleton of the aurochs, from Austria.

Verrill, Professor A. E.—Miscellaneous radiates.

Wachsmuth, Chas.—Fossil crinoids, Iowa.

Walker, Dr. Robert L., (through Agricultural Department.)—Arrowheads from Virginia.

Weile, Chas., United States Consul.—Reptiles from Guayaquil.

Weinland, Dr. D. F.—Land-shells from the Bahama and West India Islands.

Wiggins, William.—Crystallized cinnabar in quartz, California.

Williams, General A. D., (through Captain J. M. Dow.)—Pottery from San Salvador, Central America.

Williams, Dr. H. C.—Arrow-heads, Virginia, and stone implements from the same locality.

Willmuth, J. A. H.—Mounted agouti, (*Dasyprocta*,) South America, through Agricultural Department.

Wilson, Jas.—Stone implements (through the Hon. W. Townsend) from Pennsylvania.

Wilson, Dr. S. W.—Five amphiumas from Georgia.

Witter, David K.—Fossils and seeds, Iowa.

Yager, W. E.—Nest of *Tyrannus Carolinensis*, New York.

Yates, Dr. L. S.—Indian crania from mounds and stone mortar with pestle from California.

LITERARY AND SCIENTIFIC EXCHANGES.

Table showing the statistics of the Smithsonian exchanges in 1870.

Agent and country.	Number of addresses.	Number of packages.	Number of boxes.	Bulk of boxes in cubic feet.	Weight of boxes in pounds.
DR. FELIX FLÜGEL, *Leipsic:*					
Russia	84	92	......	....	....
Germany	436	486	......	....	....
Switzerland	51	60	......	....	....
Greece	6	6	......	....	....
Total	577	644	51	539	13,291
ROYAL SWEDISH ACADEMY OF SCIENCES, *Stockholm:*					
General	4	4	......	....	....
Sweden	17	41	......	....	....
Total	21	45	3	30	729
ROYAL UNIVERSITY OF NORWAY, *Christiania:*					
Norway	11	17	2	20	486
ROYAL DANISH SOCIETY OF SCIENCES, *Copenhagen:*					
Denmark	23	28	......	....	....
Iceland	1	1	......	....	....
Total	24	29	3	30	729
FREDERICK MÜLLER, *Amsterdam:*					
Holland	57	62	......	....	....
Belgium	33	36	......	....	....
Total	90	98	6	60	1,458
GUSTAVE BOSSANGE, *Paris:*					
France	165	176	......	....	....
Spain	9	11	......	....	....
Portugal	2	6	......	....	....
Algeria	2	2	......	....	....
Total	178	195	13	123	4,032
R. ISTITUTO LOMB. DI SCIENCE E LETTERE, *Milan:*					
Italy	136	144	8	80	1,944
WILLIAM WESLEY, *London:*					
Great Britain and Ireland	268	494	......	....	....
Cape Town, Africa	3	3	......	....	....
Total	271	314	20	195	5,879
Rest of the world	119	136	15	112	2,835
Grand total	1,425	1,805	121	1,189	31,383

Packages received by the Smithsonian Institution from parties in America, for foreign distribution, in 1870.

Address.	No. of packages.
ALBANY, NEW YORK.	
Albany Institute	12
Dudley Observatory	35
New York State Library	53
New York State Agricultural Society	12
New York State Homeopathic Society	17
New York State Medical Society	30
Dr. Paine	2
ANN ARBOR, MICHIGAN.	
University of Michigan	2
BOSTON, MASSACHUSETTS.	
American Academy of Arts and Sciences	263
Board of State Charities	74
Boston Society of Natural History	341
Bureau of Statistics of Labor	12
Public Library	16
Dr. T. M. Brewer	1
Dr. B. A. Gould	10
Dr. Howe, (Perkins Institute for Blind)	29
CAMBRIDGE, MASSACHUSETTS.	
Cambridge Observatory	3
American Association for Advancement of Science	8
Harvard College	68
Museum of Comparative Zoölogy	258
Professor Asa Gray	1
CHARLESTON, SOUTH CAROLINA.	
Dr. F. P. Porcher	2
CHICAGO, ILLINOIS.	
Academy of Sciences	50
Chicago Medical Times	11
CINCINNATI, OHIO.	
Observatory	36
COALBURG, WEST VIRGINIA.	
W. H. Edwards	4
COLUMBUS, OHIO.	
Ohio State Agricultural Society	89
DORCHESTER, MASSACHUSETTS.	
Dr. Edward Jarvis	30
EASTON, PENNSYLVANIA.	
Professor T. C. Porter	2
GEORGETOWN, D. C.	
Dr. A. Schott	1
HAVANA, CUBA.	
Professor F. Poey	2
INDIANAPOLIS, INDIANA.	
Institution for Deaf and Dumb	20
Institution for Education of Blind	100
State Geological Survey	400
IOWA CITY, IOWA.	
Grand Lodge of Iowa	2
Iowa Institution for Deaf and Dumb	23
Professor Hinrichs	104
JEFFERSONVILLE, INDIANA.	
S. S. Lyon	1
MEXICO.	
Mex. Soc. Mex. de Hist. Natural	25
MONTREAL, CANADA.	
Professor P. P. Carpenter	3
NEW BEDFORD, MASSACHUSETTS.	
J. H. Thomson	1
NEW HAVEN, CONNECTICUT.	
American Journal of Science	276
Connecticut Academy of Sciences	188
Professor A. E. Verrill	10
NEW YORK.	
American Institute	10
New York Lyceum of Natural History	132
American Christian Commission	1
H. Maunsell Schieffelin	500
PHILADELPHIA, PENNSYLVANIA.	
Academy of Natural Sciences	258
American Philosophical Society	718
Franklin Institute	1

Packages received from parties in America, &c.—Continued.

Address.	No. of packages.	Address.	No. of packages.
PHILADELPHIA, PA.—Continued.		SPRINGFIELD, ILLINOIS.	
Girard College	1	Professor A. H. Worthen	4
Historical Society of Pennsylvania	19	WASHINGTON, D. C.	
Pennsylvania House of Refuge	25	Bureau of Navigation	1
Pennsylvania Institute for Deaf and Dumb	25	Bureau of Statistics	100
Society for Alleviation of Miseries in Public Prisons	25	Columbia Institute for Deaf and Dumb	100
Wagner Free Institute of Science	113	Medical Department United States Army	16
Dr. Isaac Lea	36	Nautical Almanac Office	94
Dr. G. H. Horn	3	Treasury Department	18
F. Peale	1	United States Coast Survey	200
PHŒNIXVILLE, PENNSYLVANIA.		United States Agricultural Department	472
C. M. Wheatley	2	United States Naval Observatory	169
PORTLAND, MAINE.		United States Patent Office	14
Natural History Society	65	William H. Dall	30
PRINCETON, NEW JERSEY.		Dr. F. V. Hayden	68
Ezra Stockton	3	General J. A. Garfield	60
PROVIDENCE, RHODE ISLAND.		T. Pœsche	2
Dr. E. M. Snow	26	B. P. Poore	39
SALEM, MASSACHUSETTS.		WILMINGTON, DELAWARE.	
Essex Institute	165	W. M. Canby	2
Peabody Academy of Science	71	WINNEBAGO, ILLINOIS.	
Dr. A. S. Packard	16	M. S. Bebb	2
F. W. Putnam	1	ADDRESSES UNKNOWN.	
ST. PAUL, MINNESOTA.		F. N. Hasselquint	1
Minnesota Historical Society	22	A. Zeno Shindler	200
SOUTH HANOVER, INDIANA.		G. M. Levette	1
F. H. Bradley	2	Unknown	20
		Total	6,481

Packages received by the Smithsonian Institution from Europe, in 1870, *for distribution in America.*

Address.	No. of packages.
ALBANY, NEW YORK.	
Albany Institute	6
Dudley Observatory	20
New York State Agricultural Society	31
New York State Library	27
New York State Medical Society	1
New York State University	5
State Cabinet of Natural History	6
Governor of the State of New York	1
Hon. Francis C. Barlow	1
Professor James Hall	24
Dr. Woolworth	1
AMHERST, MASSACHUSETTS.	
Amherst College	4
Professor C. U. Shepard	2
ANNAPOLIS, MARYLAND.	
St. John's College	1
State Library	1
United States Naval Academy	1
ANN ARBOR, MICHIGAN.	
Observatory	12
University of Michigan	1
Major T. D. Brooks	2
Professor A. Winchell	9
APPLETON, WISCONSIN.	
Lawrence University	1
AUSTIN, TEXAS.	
State Library	2
Texas Institution for Deaf and Dumb	1
BALTIMORE, MARYLAND.	
Maryland Historical Society	7
Peabody Institute	2
S. C. Chew	1
Rev. Edwin Dalrymple	1
Dr. E. Foreman	1
Martin Lewis	1
N. H. Morrison	1
Dr. P. R. Uhler	1
BANGOR, MAINE.	
Dr. A. C. Hamlin	2
BATON ROUGE, LOUISIANA.	
Louisiana Institution for Deaf and Dumb	1
BETHLEHEM, PENNSYLVANIA.	
Lehigh University	3
BINGHAMTON, NEW YORK.	
Institution for Blind	1
BLOOMINGTON, ILLINOIS.	
Illinois Natural History Society	1
BOSTON, MASSACHUSETTS.	
American Academy of Arts and Sciences	131
American Christian Examiner	1
American Statistical Association	6
American Unitarian Association	2
Athenæum	1
Board of State Charities	1
Boston Christian Register	1
Boston Society of Natural History	195
Massachusetts Historical Society	9
New England Historico-Genealogical Society	3
North American Review	7
Prison Discipline Society	2
Public Library	23
State Library	7
Rev. W. R. Alger	3
N. Apollonio	1
Rev. Caleb D. Bradlee	1
Dr. T. M. Brewer	3
Mellen Chamberlain	1
Professor D. Cheever	1
Samuel G. Drake	1
Rev. Dr. Garnett	1
W. Lloyd Garrison	1
Dr. S. G. Howe	2
Gardiner G. Hubbard	1
Alpheus Hyatt	1
J. Norton	1
Francis Parkman	2
Captain P. W. Penhallow	1
Wendell Phillips	1
A. P. Rockwell	5
Professor W. B. Rogers	1
S. H. Scudder	4
J. A. Swan	1
Walker, Fuller & Co	7
Dr. T. H. Webb	1
Henry C. Wright	1
BROOKLINE, MASSACHUSETTS.	
Colonel T. Aspinwall	1
Professor T. Lyman	4
BROOKLYN, NEW YORK.	
Long Island Historical Society	1

Packages received from Europe, &c.—Continued.

Address.	No. of packages.
BROOKLYN, NEW YORK—Continued.	
Dr. A. Barthelmes	1
Rev. H. W. Beecher	1
J. Carson Brevoort	1
Henry C. Murphy	1
Dr. A. H. Smith	1
BRUNSWICK, MAINE.	
Bowdoin College	3
Historical Society of Maine	3
BUFFALO, NEW YORK.	
Buffalo Historical Society	2
BURLINGTON, IOWA.	
Mr. Engström	1
C. Wachmuth	1
BURLINGTON, NEW JERSEY.	
W. G. Binney	3
BURLINGTON, VERMONT.	
City Clerk	1
University of Vermont	3
CAMBRIDGE, MASSACHUSETTS.	
American Association for Advancement of Science	41
Astronomical Journal	2
Harvard College	28
Herbarium of Harvard College	2
Museum of Comparative Zoölogy	37
Observatory of Harvard College	34
Alexander Agassiz	1
Professor L. Agassiz	56
Professor Asa Gray	18
Professor J. G. Anthony	1
Dr. B. A. Gould	8
Dr. H. Hagen	3
H. T. Parker	1
Professor B. Peirce	4
J. Perry	1
Rev. T. B. Perry	1
Dr. J. Maack	8
Dr. Steindachner	1
Professor J. D. Whitney	5
Professor J. Winlock	3
Professor J. Wyman	2
CANTON, NEW YORK.	
St. Lawrence University	1
CARLISLE, PENNSYLVANIA.	
Dickinson College	2
Society of Literature	2
CAVE SPRING, GEORGIA.	
Georgia Institution for Deaf and Dumb	1
CHAPEL HILL, TEXAS.	
Soulé University	3
CHARLESTON, SOUTH CAROLINA.	
Charleston Museum	1
Elliott Society of Natural History	16
Society Library	2
South Carolina Historical Society	3
Dr. John E. Holbrook	1
CHARLESTOWN, NEW HAMPSHIRE.	
Dr. S. Webber	1
CHARLOTTESVILLE, VIRGINIA.	
University of Virginia	4
CHICAGO, ILLINOIS.	
Chicago Academy of Sciences	59
Chicago College of Pharmacy	1
Board of Trade	3
Dearborn Observatory	8
Historical Society of Chicago	1
Insane Asylum	1
Medical Times	2
Andrew Bolter	1
S. A. Briggs	1
M. De la Fourtrie	1
T. H. Safford	2
Charles Sonnes	1
Dr. W. Stimpson	7
CINCINNATI, OHIO.	
American Freemason	1
American Medical College	1
Astronomical Observatory	21
Historical and Philosophical Society	2
Mercantile Library Association	1
City Clerk	1
Dr. Cleveland Abbe	1
J. G. Anthony	1
Daniel Vaughan	1
CLINTON, NEW YORK.	
Observatory of Hamilton College	3
Dr. C. H. F. Peters	3
COALBURGH, WEST VIRGINIA.	
W. H. Edwards	1

Packages received from Europe, &c.—Continued.

Address.	No. of packages.
COLUMBIA, MISSOURI.	
Geological Survey of Missouri	2
University of Missouri	2
Dr. G. C. Swallow	1
COLUMBIA, SOUTH CAROLINA.	
South Carolina College	2
State Library	1
COLUMBUS, OHIO.	
Institution for Deaf and Dumb	1
Ohio State Board of Agriculture	53
Leo Lesquereux	4
CONCORD, NEW HAMPSHIRE.	
New Hampshire Historical Society	4
State Lunatic Asylum	1
COUNCIL BLUFFS, IOWA.	
Iowa Institution for Deaf and Dumb	1
DANVILLE, KENTUCKY.	
Kentucky Institution for Deaf and Dumb	1
DECORAH, IOWA.	
Norwegian Luther College	3
DELAWARE, OHIO.	
Ohio Wesleyan University	1
DELAVAN, WISCONSIN.	
Wisconsin Institution for Deaf and Dumb	1
DES MOINES, IOWA.	
Geological survey of Iowa	1
Governor of the State of Iowa	1
State Library	6
DETROIT, MICHIGAN.	
Michigan State Agricultural Society	8
DORCHESTER, MASSACHUSETTS.	
Dr. Edward Jarvis	12
DURHAM CENTRE, CONNECTICUT.	
Rev. W. Fowler	1

Address.	No. of packages.
EAST GREENWICH, NEW YORK.	
Asa Fitch	1
EASTON, PENNSYLVANIA.	
Lafayette College	3
Professor T. C. Porter	1
EVANSTON, ILLINOIS.	
Northwestern University	2
FAIRIBAULT, MINNESOTA.	
Minnesota Institution for Deaf and Dumb	1
FALL RIVER, MASSACHUSETTS.	
Niel Arntzen	1
FLINT, MICHIGAN.	
Michigan Asylum for Deaf and Dumb	1
FORT MACON, NORTH CAROLINA.	
Dr. E. Coues	1
FRANKFORT, KENTUCKY.	
Geological Survey of Kentucky	4
FREDERICK, MARYLAND.	
Maryland Institution for Deaf and Dumb	1
FREDERICKTON, NEW BRUNSWICK.	
King's College	1
Legislative Library	1
FULTON, MISSOURI.	
Missouri Asylum for Deaf and Dumb	1
GALESBURG, ILLINOIS.	
Lombard University	1
GALESVILLE, WISCONSIN.	
Galesville University	1
GAMBIER, OHIO.	
Kenyon College	2

Packages received from Europe, &c.—Continued.

Address.	No. of packages.
GENEVA, NEW YORK.	
Professor H. L. Smith	1
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Georgetown College	4
GRAND RAPIDS, MICHIGAN.	
E. O. Currier	1
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Indiana Asbury University	1
HALIFAX, NOVA SCOTIA.	
Nova Scotian Institute of Natural Sciences	2
Professor George Lawson	1
HAMILTON, NEW YORK.	
Madison University	1
Rev. A. C. Kendrick	1
HAMPDEN SYDNEY, VIRGINIA.	
Hampden Sydney College	1
HANOVER, NEW HAMPSHIRE.	
Dartmouth College	4
HAVANA, CUBA.	
Professor F. Poey	2
HARRISBURG, PENNSYLVANIA.	
Medical Society of the State of Pennsylvania	2
State Library	2
HARTFORD, CONNECTICUT.	
American Asylum for Deaf and Dumb	1
Historical Society of Connecticut	2
Insane Asylum	1
Young Men's Institute	1
Trinity College	1
HUDSON, OHIO.	
Western Reserve College	1
INDIANAPOLIS, INDIANA.	
Indiana Historical Society	3
INDIANAPOLIS, IND.—Continued.	
Indiana Institute for Blind	2
Indiana Institution for Deaf and Dumb	1
Dr. W. W. Butterfield	1
INMANSVILLE, WISCONSIN.	
Wisconsin Scandinavian Society	1
IOWA CITY, IOWA.	
Grand Lodge	1
Iowa State University	21
Professor G. Hinrichs	1
Dr. C. A. White	1
ITHACA, NEW YORK.	
Cornell College	3
Dr. Wesley Newcomb	1
Professor Goldwin Smith	1
JACKSON, MISSISSIPPI.	
State Library	1
J. S. B. Thacker	1
JACKSONVILLE, ILLINOIS.	
Illinois Institute for Blind	1
Illinois Institution for Deaf and Dumb	1
JEFFERSON CITY, MISSOURI.	
Historical and Philosophical Society	2
KEYTESVILLE, MISSOURI.	
Charles Veatch	2
KINGSTON, CANADA.	
Botanical Society of Canada	2
Queen's College	1
KNOXVILLE, TENNESSEE.	
Tennessee School for Deaf and Dumb	1
LEBANON, TENNESSEE.	
Cumberland University	1
LEWISBURG, PENNSYLVANIA.	
University	1
LEXINGTON, KENTUCKY.	
Rev. T. W. Coit	1

Packages received from Europe, &c.—Continued.

Address.	No. of packages.
LEXINGTON, VIRGINIA.	
M. F. Maury	4
LITTLE ROCK, ARKANSAS.	
Arkansas Institution for Deaf and Dumb	1
State Library	15
State University	2
LOUISVILLE, KENTUCKY.	
City Clerk	1
Grand Lodge	1
University of Louisville	2
Historical Society of Kentucky	1
LYNN, MASSACHUSETTS.	
Massachusetts Society of Natural History	1
MADISON, WISCONSIN.	
Emigranten	1
Historical Society of Wisconsin	5
State Library	1
Wisconsin State Agricultural Society	16
Dr. P. A. Chadbourne	1
Mr. Hill	1
MIDDLETOWN, CONNECTICUT.	
Wesleyan University	1
MILLEDGEVILLE, GEORGIA.	
State Library	1
University	1
MILWAUKEE, WISCONSIN.	
Increase A. Lapham	1
MONTGOMERY, ALABAMA.	
State Library	1
MONTPELIER, VERMONT.	
Historical and Antiquarian Society of Vermont	3
State Library	4
Dr. Albert Hager	1
MONTREAL, CANADA.	
Geological Survey of Canada	7
McGill College	2
Montreal Historical Society	1
MONTREAL, CANADA—Continued.	
Natural History Society	35
Observatory	2
E. Billings	3
Professor P. P. Carpenter	1
Professor J. W. Dawson	9
Professor J. Sterry Hunt	1
Sir William Logan	8
NASHVILLE, TENNESSEE.	
State Library	1
University of Nashville	1
Rev. Philip Lindsley	1
NATCHEZ, MISSISSIPPI.	
William P. Miller	1
NEENAH, WISCONSIN.	
Scandinavian Library Association	3
NEWARK, NEW JERSEY.	
Historical Society of New Jersey	1
NEW BEDFORD, MASSACHUSETTS.	
William Hathaway, jr	2
NEW BRUNSWICK, NEW JERSEY.	
Geological Survey of New Jersey	4
Professor George H. Cooke	1
NEW HAVEN, CONNECTICUT.	
American Journal of Science and Arts	70
American Oriental Society	21
Connecticut Academy of Arts and Sciences	28
New Haven Museum	1
Yale College	18
Professor W. P. Blake	3
Hon. C. W. Bradley	1
Professor W. H. Brewer	1
Professor G. J. Brush	6
Professor J. D. Dana	35
Professor D. C. Eaton	1
Professor E. Loomis	10
Professor C. S. Lyman	3
Professor C. O. Marsh	4
Professor H. A. Newton	7
Dr. Sherman	1
Professor B. Silliman	12
Professor A. C. Twining	1
Professor A. E. Verrill	5
Professor W. D. Whitney	8
Professor T. D. Woolsey	1

Packages received from Europe, &c.—Continued.

Address.	No. of packages.
NEW ORLEANS, LOUISIANA.	
City Clerk	1
New Orleans Academy of Natural Sciences	48
University of Louisiana	1
Dr. Bennet Dowler	6
Dr. J. O. Noyes	2
NEW YORK, NEW YORK.	
American Bureau of Mines	1
American Christian Commission	16
American Ethnological Society	14
American Geographical and Statistical Society	30
American Journal of Mining	4
American Journal of Obstetrics	1
American Institute	13
American Microscopical Society	1
American Museum of Natural History	2
Astor Library	9
Central Park Observatory	2
Columbia College	2
Cooper Institute	2
Editor Homœopathic Sun	1
Editor Medical Gazette	1
Herbarium of Columbia College	2
Historical Society	7
Institution for Improved Instruction for Deaf and Dumb	2
Lyceum of Natural History	82
Mercantile Library Association	2
Metropolitan Board of Health	1
Mexican consul	1
New York Academy of Medicine	5
New York Christian Enquirer	3
School of Mines	2
United States Sanitary Commission	9
University	3
Dr. F. A. P. Barnard	1
Rev. Dr. Bellows	1
T. Bland	1
Dr. W. Baeck	1
Alexander W. Bradford	1
Dr. C. F. Chandler	2
Dr. S. Cutting	1
Dr. E. H. Davis	1
Captain J. M. Dow	3
Dr. H. Draper	7
Rev. John P. Durbin	1
Daniel W. Fisk	1
Professor H. Flügel	1
Henry Grinnell	4
Dr. E. Harris	1
Professor Waterhouse Hawkins	1
E. A. Hopkins	1
Professor C. A. Joy	2
Dr. J. P. Kimball	1
George N. Lawrence	4

Address.	No. of packages.
NEW YORK, N. Y.—Continued.	
James Lenox	1
C. Loosey, Consul General of Austria	1
Dr. B. W. McCrady	1
Dr. J. S. Newberry	7
Dr. J. C. Nott	3
Baron R. Osten-Sacken	1
Messrs. Parker & Douglas	5
Brother Paulian, Manhattan College	1
Professor Charles Rau	1
Hon. S. B. Ruggles	1
E. G. Squier	7
F. R. Stallknecht	1
Professor John Torrey	1
Prosper M. Wetmore	1
E. C. Wines	1
NORTHAMPTON, MASS.	
Clarke Institution for Deaf and Dumb	1
NOTRE DAME, INDIANA.	
Sister Angela Gillespie	1
OLATHE, KANSAS.	
Kansas Institution for Deaf and Dumb	1
OLYMPIA, WASHINGTON TERRITORY.	
State Library	1
OMAHA, NEBRASKA.	
Nebraska Institution for Deaf and Dumb	1
OTTAWA, CANADA.	
Legislative Library of Canada	2
OXFORD, OHIO.	
Miami University	1
OXFORD, MISSISSIPPI.	
University of Mississippi	1
E. W. Hilgard	4
PEORIA, ILLINOIS.	
Dr. F. Brendel	3
PHILADELPHIA, PENNSYLVANIA.	
American Journal of Conchology	3
Academy of Natural Sciences	177

Packages received from Europe, &c.—Continued.

Address.	No. of packages.
PHILADELPHIA, PA.—Continued.	
American Entomological Society	9
American Journal of Medical Science	1
American Pharmaceutical Association	28
American Philosophical Society	121
Board of Controllers of Public Schools	1
Central High School	5
Franklin Institute	26
Girard College	1
Historical Society of Pennsylvania	12
House of Refuge	1
Library Company	3
Magnetic and Meteorological Observatory	2
North American Medico-Chirurgical Review	7
Numismatic and Antiquarian Society	2
Observatory of Girard College	3
Pennsylvania Institute for Blind	1
Pennsylvania Institute for Deaf and Dumb	2
Wagner Free Institute of Science	5
James Barclay	1
Rev. E. R. Beadle	1
Professor H. Bigelow	1
Lorin Blodget	3
Dr. D. D. Brinton	1
H. C. Carey	3
J. Cassin	2
G. W. Childs	2
Dr. B. H. Coates	2
T. A. Conrad	2
Professor E. D. Cope	6
Professor E. T. Cresson	1
Dr. Isaac Hays	1
Dr. G. H. Horn	1
S. P. James	1
Dr. Isaac Lea	9
Dr. J. L. Le Conte	3
Professor J. Leidy	8
Professor J. P. Lesley	2
Dr. J. A. Meigs	5
J. G. Morris	1
J. Redfield	1
Dr. J. H. M. Packard	1
W. Sharswood	1
George W. Tryon, jr	6
Professor W. Wagner	1
Dr. E. Ward	1
PHŒNIXVILLE, PENNSYLVANIA.	
Charles M. Wheatley	2
PORTLAND, MAINE.	
City Registrar	1
Portland Society of Natural History	30
POUGHKEEPSIE, NEW YORK.	
Vassar College	2
PRINCETON, NEW JERSEY.	
College of New Jersey	7
Albert D. Brown	2
Professor A. Guyot	7
PROVIDENCE, RHODE ISLAND.	
Brown University	4
Registrar General of Rhode Island	1
Rhode Island Historical Society	5
John R. Bartlett	1
John Carter Brown	1
Professor Alexis Caswell	2
Romeo Elton	1
Dr. Edwin M. Snow	4
QUEBEC, CANADA.	
Laval University	1
Literary and Historical Society	10
Observatory	1
RALEIGH, NORTH CAROLINA.	
North Carolina Institution for Deaf and Dumb	1
State Library	1
RICHMOND, VIRGINIA.	
Historical Society of Virginia	2
State Library	2
T. H. Wynne	1
ROCHESTER, NEW YORK.	
University	1
SACRAMENTO, CALIFORNIA.	
Geological Survey of California	2
State Library	2
ST. ANTHONY, MINNESOTA.	
University of Minnesota	1
ST. LOUIS, MISSOURI.	
Deutsches Institut zur Beförderung der Wissenchaften	2
Catholic Institution for Deaf and Dumb	1
City Clerk	1
Medical and Surgical Journal	5
St. Louis Academy of Sciences	84

Packages received from Europe, &c.—Continued.

Address.	No. of packages.
ST. LOUIS, MO.—Continued.	
University	5
Ernst von Angelrodt	1
Dr. G. Baumgarten	1
Professor William Chauvenet	1
Dr. G. Engelmann	1
G. F. Gauley	1
Maurice Schuster	1
ST. JOHN, NEW BRUNSWICK.	
Library of Mechanics' Institute	1
Natural History Society	1
ST. PAUL, MINNESOTA.	
Minnesota Historical Society	7
J. H. Kloos	4
ST. THOMAS, WEST INDIES.	
Professor Krebs	1
SALEM, MASSACHUSETTS.	
Essex Institute	62
Peabody Academy of Science	35
Dr. A. S. Packard	9
Professor F. W. Putnam	1
E. Morse	1
SAN FRANCISCO, CALIFORNIA.	
California Academy of Natural Sciences	68
California Institution for Deaf and Dumb	1
James Behrens	1
H. G. Bloomer	1
Henry Bolander	3
R. E. C. Stearns	7
SAVANNAH, GEORGIA.	
Historical Society of Georgia	2
SHARON, CONNECTICUT.	
John C. Smith	1
SING SING, NEW YORK.	
Dr. G. J. Fisher	4
SPRINGFIELD, ILLINOIS.	
Editor of Masonic Trowel	1
Professor H. A. Worthen	6
STAUNTON, VIRGINIA.	
Virginia Institution for Deaf and Dumb	1
SWANTON, CANADA.	
Dr. Perry	1
TALLADEGA, ALABAMA.	
Alabama Institution for Deaf and Dumb	1
TORONTO, CANADA.	
Canadian Institute	15
Literary and Historical Society	1
Magnetic Observatory	9
Trinity College Library	1
University of Canada	5
TUSCALOOSA, ALABAMA.	
University	1
URBANA, OHIO.	
University of Urbana	1
UTICA, NEW YORK.	
American Journal of Insanity	5
Colonel E. Jewett	2
VANDALIA, ILLINOIS.	
Illinois Historical and Archæological Society	1
WASHINGTON, D. C.	
American Annals of the Deaf and Dumb	1
American Nautical Almanac	2
Bureau of Navigation	5
Bureau of Statistics	3
Census Bureau	4
Department of Agriculture	102
Department of Education	4
Engineer Department	3
General Land Office	6
Hospital for Insane	1
Howard University	1
Hydrographic Office	11
Interior Department	1
Library of Congress	48
Light-House Board	1
Mexican minister	1
National Academy of Science	50
National Deaf-mute College	1
Navy Department	1
President of the United States	3
Quartermaster General's Office	1
Ordnance Bureau	1
Secretary of the Navy	1

Packages received from Europe, &c.—Continued.

Address.	No. of packages.	Address.	No. of packages.
WASHINGTON, D. C.—Continued.		WASHINGTON, D. C.—Continued.	
Secretary of War	6	Professor G. Schaeffer	1
State Department	3	Mrs. H. Schoolcraft	2
Surgeon General's Office	95	Charles A. Schott	2
Survey of North American Lakes	1	Hon. F. E. Spinner	1
Treasury Department	1	Henry Ulke	5
United States Boundary Commission	1	D. A. Wells	1
United States Coast Survey	48	Lieutenant Colonel Williamson	1
United States Naval Observatory	97	Dr. J. G. Woodward	2
United States Patent Office	113	WATERVILLE, MAINE.	
Washington Public Schools	5		
Professor S. F. Baird	16	Waterville College	2
Surgeon General Barnes	1		
H. D. Barnard	1	WESTERVILLE, OHIO.	
S. M. Clark	1		
Professor J. H. C. Coffin	3	Otterbein University	1
W. H. Dall	5		
Admiral Davis	1	WEST POINT, NEW YORK.	
Dr. W. B. Drinkard	1		
W. Ferrel	1	United States Military Academy	1
W. Q. Force	2		
General J. C. Frémont	4	WILLIAMSBURG, VIRGINIA.	
Baron von Gerolt	1		
Professor T. Gill	5	Eastern State Lunatic Asylum	1
Dr. F. V. Hayden	3		
Dr. Hayes	1	WILMINGTON, DELAWARE.	
Professor J. Henry	28		
F. B. Hough	1	W. M. Canby	3
General A. A. Humphreys	1		
Admiral S. P. Lee	1	WINDSOR, NOVA SCOTIA.	
L. W. Meech	1		
F. B. Meek	15	Library of King's College	1
Professor S. Newcomb	2		
D. F. M. Otis	1	WINNEBAGO, ILLINOIS.	
Dr. G. A. Otis	1		
Hon. Peter Parker	1	M. S. Bebb	3
T. R. Peale	1		
Count de Pourtales	2	WORCESTER, MASSACHUSETTS.	
Commodore Sands	1		
Joseph Saxton	2	American Antiquarian Society	8

Total addresses of institutions	306
Total addresses of individuals	261
	567
Total number of parcels to institutions	2,949
Total number of parcels to individuals	756
	3,705

LIST OF METEOROLOGICAL STATIONS AND OBSERVERS OF THE SMITHSONIAN INSTITUTION FOR THE YEAR 1870.

[B signifies Barometer; P, Psychrometer; T, Thermometer; R, Rain-gauge; N, no instrument.]

Station.	Name of observer.	North latitude.	West longitude.	Height.	Instruments.	No. months received.
BRITISH AMERICA.		° ′ ″	° ″	*Feet.*		
Stanbridge, Quebec	Gilmour, A. H. J.	45 08	73	222	T R	12
Acadia College, Wolfville, N. S	Higgins, Prof. D. F.	45 06	64 25	80	B P T R	9
Clifton, Ontario	Jones, W. Martin				T	11
St. John, New Brunswick	Murdock, G.	45 16 42	66 3 45	135	B P T R	11
Winnipeg, Manitoba	Stewart, James	49 52	97	650	B P T R	6
BERMUDA.						
Center Signal Station, St. George's	Royal Engineers, (in the Royal Gazette.)				B P T R	12
MEXICO.						
Mirador, Vera Cruz	Sartorius, Dr. C.	19 15	96 25	3,600	B P T R	12
ALABAMA.						
Carlowville, Dallas Co	Alison, H. L., M. D	32 10	87 15	300	T R	12
Selma, Dallas Co	Fahs, C. F., M. D	32 30	87 10	236	B P T R	7
Havana, Hale Co	Jennings, S. K., M. D	32 30	87 41	500	T R	1
Coatopa, Sumter Co	Jennings, S. K., M. D				T R	11
Near Elyton, Jefferson Co	Shields, Miss E. B				T R	12
Mobile, Mobile Co	Taylor, L. B	30 41.34	88 10	14	T R	2
Greene Springs School, Hale Co.	Tutwiler, H.	32 50	87 46	500	T R	12
Fish River, Baldwin Co	Vankirk, W. J.				T R	12
ARKANSAS.						
Mineral Springs, Hempstead Co.	Bishop, H.	34	93		T R	5
Fayetteville, Washington Co.	McClung, C. L.	36 2	94 10	1,350	T R	3
Helena, Phillips Co	Russell, O. F.	34 32 52	90 08 46		T	12
CALIFORNIA.						
Visalia, Tulare Co	Blake, J. W.	36 35	119 17		B P T R	12
Monterey, Monterey Co	Canfield, C. A., M. D.	36	121 52	34	B P T R	12
Chico, Butte Co	Cheney, W. F., M. D.	39 44 45	121 44 37	150	T R	11
Watsonville, Santa Cruz Co	Compton, A. J., M. D.	36 56		45	T R	11
Clayton, Contra Costa Co.	McClung, C. L.	37 56	121 40	76	T R	4
Benicia, Solano Co	Naval Hospital	38 06 19	122 15 19	2,954	B T R	3
Indian Valley, Plumas Co.	Pulsifer, Mary E.			3,280	T	2
Vacaville, Solano Co	Simmons, Prof. J. C.	38 21 21	121 58 23	175	B T R	4
Cahto, Mendocino Co	Thornton, Dr. W. W	40	125	1,500	T R	12
COLORADO.						
Denver, Arapahoe Co	Byers, W. W. & S. T. Sopris	39 47	105 05	5,350	T R	12
CONNECTICUT.						
North Greenwich, Fairfield Co.	Alcott, William P	41 5 30	73 41 40	300	B T R	3
Southington, Hartford Co.	Andrews, L.				T R	9
Middletown, Middlesex Co.	Johnston, John	41 33	72 39	205	B P T R	12
Colebrook, Litchfield Co	Rockwell, Charlotte	42	73 3	1,210	T R	11
Brookfield, Fairfield Co	Roe, Rev. S. W.	42 27	73 33	100	T R	12
Columbia, Tolland Co	Yeomans, W. G.	41 40	72 42		T R	12
DELAWARE.						
Dover, Kent Co	Bateman, J. H	39 10	75 30		T R	6
Milford, Kent Co.	Phillipps, Mrs. W. R.	38 55	75 30		T R	12
FLORIDA.						
White Spring, Hamilton Co.	Adams, R. W.				T	2
St. Augustine, St. John's Co	Atwood, G. W	30	81 30	10	T R	6

List of meteorological stations and observers, &c., for the year 1870—Continued.

Station.	Name of observer.	North latitude.	West longitude.	Height.	Instruments.	No. months received.
FLORIDA—Cont'd.		° ′ ″	° ′ ″	*Feet.*		
Jacksonville, Duval Co	Baldwin, A. S., M. D.	30 15	82	20	B P T R	12
Ocala, Marion Co	Barker, E.				T	7
Newport, Wakulla Co	Beecher, Rev. C.	30 10			P T R	8
Twelve miles north of Mosquito Inlet, Volusia Co.	Chamberlain, S. N			10	T R	5
Orange Grove, Manatee Co	Clarke, W. J	27 28	82 35	10	T R	5
Manatee, Manatee Co	Coachman, B. A	27 30	82 45	6	T R	9
Port Orange, Volusia Co	Hawks, Mrs. E. H				T	7
Biscayne, Dade Co	Hunt, W. H	25 45	80 16	12	T R	1
Chattahoochee Arsenal, Gadsden Co.	Martin, M	30 48	84 48	180	T R	6
Pilatka, Putnam Co	Robinson, Gen'l G. D.	29 36	81 37	152	P T R	11
GEORGIA.						
St. Mary's, Camden Co	Barker, E	30 40 23	81 26 20	15	T R	8
Near Quitman, Brooks Co	Cutter, John L.	30 45	83 30 30		T R	1
Atlanta, Fulton Co	Deckner, F., and son	33 45	84	1,050	T R	8
Columbus, Muscogee Co	Fogarty, N. J				T R	1
St. Mary's, Camden Co	Hillyer, H. L	30 50	81 40	25	T R	3
Berne, Camden Co	Hillyer, H. L				T R	9
Penfield, Greene Co	Sanford, S. P				T R	12
ILLINOIS.						
Elmore, Peoria Co	Adams, W. H				R	11
Pleasant Ridge, Bureau Co	Aldrich, Verry	41 15	89 15	550	T	7
Sandwich, De Kalb Co	Ballou, N. E	41 31	88 30	665	B P T R	4
Elmira, Stark Co	Blanchard, O. A	41 12	90 15		T R	3
Andalusia, Rock Island Co	Bowman, E. H., M. D.	41 25	90 46		B T	11
Peoria, Peoria Co	Brendel, F	40 43	89 30	440	B P T R	12
Springfield, Sangamon Co	Brinkerhoff, G. W	39 48	89 33		T	8
Chicago, Cook Co	Brookes, S	42	87		T	12
Alto, Lee Co	Carey, Daniel	41 45	89		T	9
Louisville, Clay Co	Chase, D. H., M. D	38 40	88 30		T R	12
Havana, Mason Co	Cochrane, J	40 20	89 50	475	T R	4
Decatur, Macon Co	Dudley, T	39 40	89 10		T R	12
Mount Sterling, Brown Co	Duncan, Rev. A	40	91 15		T R	12
Golconda, Pope Co	Eldredge, W. V	37 41	88 46		T R	9
Pana, Christian Co	Finley, T., M. D	39 24 21	89 6 5	735	T R	12
Near South Pass, Union Co	Freeman, H. C				T	2
Charleston, Coles Co	Gramesly, C	39 31	88 14		T R	9
Manchester, Scott Co	Grant, J. and C. W	39 33	90 14 36		B P T R	12
Wapella, De Witt Co	Groff, T. Louis	40 11	89 07		N	1
Quincy, Adams Co	Hearne, F. I	39 54	91 26		T R	8
Mattoon, Coles Co	Henry, W. E	39 29 10.5	45 20 38	740	T R	12
Marengo, McHenry Co	James, I. W	42 13	88 31	780	T R	12
Waterloo, Monroe Co	Jozefe, C., M. D	38 30	90 30		T	3
Chicago, Cook Co	Langguth, J. G	42	87 30	600	B P T R	12
Galesburg, Knox Co	Livingston, Prof. W	40 55	90 25		B P T R	12
Evanston, Cook Co	Marcy, Prof. Oliver	42 1	87 38	570	B T R	12
Augusta, Hancock Co	Mead, S. B	40 10	91		P T R	12
Ottawa, La Salle Co	Merwin, Mrs. E. H	41 20	88 47		T R	12
Belvidere, Boone Co	Moss, G. B	42 15	88 47	810	T R	12
Hennepin, Putnam Co	Osborn, N	41 30	89 20		T	12
Oquawka, Henderson Co	Patterson, H. N	41 8	90 30		T R	6
Near Wyanet, Bureau Co	Phelps, E. S. and Miss L. E.	41 30	89 45		T R	11
Aurora, Kane Co	Spaulding, A. and Mrs. E. D.	41 45	88 22	696	B T R	12
Dubois, Washington Co	Spencer, W. C	38 14	89 16	405	T R	12
Effingham, Effingham Co	Thompson, W., M. D	39 3	88 5	592	T R	1
Winnebago, Winnebago Co	Tolman, J. W. and Miss.	42 17	89 12	900	B T R	12
Warsaw, Hancock Co	Whitaker, B	40 20	91 31		T R	11
INDIANA.						
Near Laporte, Laporte Co	Andrew, F. G			770	T R	12
Mount Carmel, Franklin Co	Applegate, J. A., and daughter.	39 22	84 51	900	T R	12
Vevay, Switzerland Co	Boerner, C. G	38 46	84 59 20.5	525	B P T R	12
New Harmony, Posey Co	Chappelsmith, J	38 08	87 50	350	B P T R	12
Laconia, Harrison Co	Crosier, A	37 47	85 50		T R	12
Spiceland, Henry Co	Dawson, W	39 48	85 18	1,025	B T R	12

List of meteorological stations and observers, &c., for the year 1870—Continued.

Station.	Name of observer.	North latitude.	West longitude.	Height.	Instruments.	No. months received.
INDIANA—Continued.		° ′ ″	° ′ ″	*Feet.*		
Knightstown, Rush Co	Deem, D	39 46	85 24	800	B P T R	12
Merom, Sullivan Co	Holmes, T	39 05	87 40	......	T R	9
Muncie, Delaware Co	Kemper, G. W. H., M. D	40 12	85 16	......	T R	5
Rensselaer, Jasper Co	Loughridge, J. H., M. D	40 56	87 13	725	T R	9
Columbia City, Whitley Co	McCoy, Dr. F. and Miss	41 10	85 30	......	T R	11
Merom, Sullivan Co	McHenry, B. F	39 05	87 40	......	T R	2
La Fayette, Tippecanoe Co	Newton, J. W	....	....	......	B T R	1
Fort Wayne, Allen Co	Robertson, R. S	41	85	800	T R	2
Kentland, Newton Co	Spitler, D	40 56	87 12	725	T R	2
Aurora, Dearborn Co	Sutton, G	39 5 54	84 54	509	B P T R	12
Harveysburg, Fountain Co	Williams, Mrs. B. C	39 55	87 40	......	T R	9
Annapolis, Park Co	Williams, Mrs. B. C	....	....	......	T R	2
Indianapolis, Marion Co	Woolen, Dr. G. V., and others.	39 47	87 6	698	B P T R	11
IOWA.						
Boonesborough, Boone Co	Babcock, E	42	93 14	1,160	T R	12
Vawter's Grove, Adair Co	Bryant, Mrs. J. A	41 20	94 30	1,500	T R	11
Mount Vernon, Linn Co	Collin, Prof. A	42	91 30	......	T	12
Webster City, Hamilton Co	Croft, Clayton I	42 30	94	......	T	10
Guttenberg, Clayton Co	Dickenson, J. P	43	90 50	690	T	12
Near Algona, Kossuth Co	Dorweiler, P	43	94 26	1,500	T	8
Near Newton, Jasper Co	Failor, A	42	94	......	T R	1
Clinton, Clinton Co	Farnsworth, P. J	41 47	90 10	630	T R	12
Waukon, Iowa Co	Hancock, E. M	....	....	......	T R	9
Dubuque, Dubuque Co	Horr, Asa, M. D	42 30	90 39 51	666	B P T R	11
West Union, Fayette Co	McClintock, F	42 58	91 50	1,300	B T R	12
Near Fort Madison, Lee Co	McCready, D	40 37	91 28	......	T R	12
Grant City, Sac Co	Miller, E. and R	42 16	94 57 36	......	T R	11
Monticello, Jones Co	Moulton, M. M	42 15	91 15	800	T R	12
Sac City, Sac Co	Nelson, D. B	42 20	95	900	T R	5
Iowa City, Johnson Co	Parvin, Prof. T. S	41 36 53	91 30 10	......	B P T R	12
Waterloo, Black Hawk Co	Steed, T	42 30	92 30	......	T	8
Harris Grove, Harrison Co	Stern, Jacob F	41	95	928	T R	12
Near Rolfe, Pocahontas Co	Strong, Oscar I	42 50	94 34	1,000	T R	2
Mineral Ridge, Boone Co	Sullivan, Z. T	42 6	93 40	1,200	T R	3
Spring Grove, Hardin Co	Townsend, N	42 32	93 20	......	T R	9
The Woodlands, Floyd Co	Wadey, H	43	93	......	T	12
Muscatine, Muscatine Co	Walton, J. P	41 25	91 02	582	B T R	3
Independence, Buchanan Co	Warne, G., M. D	42 25	92 06	940	B T R	12
Near Independence, Buchanan Co.	Wheaton, Mrs. D. B	42 29 25	91 50 08	......	T R	12
Whitesboro, Harrison Co	Witter, D. K. and M. E	41 38	95 40	......	T R	12
Algona, Kossuth Co	Warren, J. H	43 05	94 15	......	T	11
Bowen's Prairie, Jones Co	Woodworth, S	42 15	....	800	B T R	12
KANSAS.						
Olathe, Johnson Co	Beckwith, W	38 50	94 30	......	T R	12
Near Ames, Story Co	Cotton, J. M	42	93 30	790	T R	1
Williamstown, Jefferson Co	Cotton, J. M., and E. Adams.	39	95 30	......	T R	5
Burlington, Coffey Co	Crocker, A	38 08	95 27	825	R	5
Crawfordsville, Crawford Co	Daniels, P	37 53	94 85	......	T R	5
Neosho Falls, Woodson Co	Groesbeck, Mrs. E. W	37	....	......	T R	4
Atchison, Atchison Co	Horn, Dr. H. B. and Miss C.	39 42	95	1,000	T R	12
Baxter Springs, Cherokee Co	Ingraham and Hyland	37 03	94 37	......	T R	12
Douglass, Butler Co	Lamb, Dr. W. M	37 33	97 03	......	T R	6
Manhattan, Riley Co	Mudge, Prof. B. F	39 12	96 40	1,300	B T R	12
Near Leroy, Coffey Co	Shoemaker, J. G	38 06 28	95 27 39	......	B T R	4
Lawrence, Douglass Co	Snow, Prof. F. H	38 55	95 15	850	B P T R	12
Leavenworth, Leavenworth Co	Stayman, Dr. J	39 20	94 33	787	T R	12
Paola, Miami Co	Walrad, L. D	38 30	95 30	......	T R	12
Holton, Jackson Co	Walters, Dr. J	39 27	95 10	1,172	T	12
Council Grove, Morris Co	Woodworth, A	38 40	96 30	......	T R	12
KENTUCKY.						
Danville, Boyle Co	Beatty, O	37 40	84 30	900	B T R	9
Louisville, Jefferson Co	Blackburn, Dr. C. B	....	....	......	B P T R	1
Pine Grove, Clark Co	Martin, Dr. S. D	38 04	....	978	B P T R	12
Arcadia, Lincoln Co	Shriver, H	37 34	84 30	900	B P T R	11
Springdale, Jefferson Co	Young, Mrs. L	38 06 55	85 24 13	570	B P T R	12

List of meteorological stations and observers, &c., for the year 1870—Continued.

Station.	Name of observer.	North latitude.	West longitude.	Height.	Instruments.	No. months received.
LOUISIANA.		° ′ ″	° ′ ″	*Feet.*		
Anchorage Plantat'n, Bossier Par	Carter, J. H	32 30	93 45	......	T	11
Ponchatoula, Tangipahoa Par	Collins, H. C	30 30	90 20	......	B T R	2
New Orleans, Orleans Par	Foster, Captain R. W	....	....	......	B T R	12
Cheneyville, Rapides Par	Jackson, R. S	31	92 20	......	T	9
MAINE.						
Houlton, Aroostook Co	Fernald, C. H	46 07	67 49 24	470	T R	12
Orono, Penobscot Co	Fernald, M. C	44 53 10	68 38 57	134	B P T R	12
Gardiner, Kennebec Co	Gardiner, R. H	44 0 55	69 45 50	......	B P T R	12
Cornish, York Co	Guptill, G. W	43 40	70 44	800	T R	12
Lisbon, Androscoggin Co	Moore, Asa P	44	70 4	130	T R	12
Standish, Cumberland Co	Moulton, J. P	43 45	70 30	280	T R	1
Steuben, Washington Co	Parker, J. D	44 31 21	67 37 34	50	T R	4
Mount Desert, Hancock Co	Parker, J. D	....	....	......	T R	7
Williamsburg, Piscataquis Co	Pitman, Edwin	45 21	69 71	......	T R	11
Oxford, Oxford Co	Smith, H. D	44 08	70 33	......	T R	12
Surry, Hancock Co	Tripp, Oscar H	44 30	68 30	50	T R	6
Cornish, York Co	West, Silas	43 33	70 50	784	B T R	12
West Waterville, Kennebec Co	Wilbur, Benjamin F	44 30	69 46	......	T R	12
MARYLAND.						
Fallston, Harford Co	Curtis, G. G	39 30	....	300	T R	3
Annapolis, Anne Arundel Co	Goodman, W. R	38 58	76 29	20	B P T R	12
Frederick, Frederick Co	Hanshew, H. K	39 24	77 26 30	......	B T R	6
Emmittsburg, Frederick Co	Jourdan, Prof. C. H	39 40	77 20	......	B P T R	12
Woodlawn, Cecil Co	McCormick, J. O	39 38	76 04	......	B T R	12
St. Mary's City, St. Mary's Co	Stephenson, Rev. J	38 10	76 30	45	T R	2
Woodstock College, Baltimore Co	Valentine, A. X	39 55	76 52	400	T R	1
MASSACHUSETTS.						
Boston, Suffolk Co	Appleton, F. H	42 20	71	......	T	1
Richmond, Berkshire Co	Bacon, W	42 23	73 20	1,000	T R	10
West Newton, Middlesex Co	Bixby, J. H	42 21	71 17	55½	T R	10
Newbury, Essex Co	Caldwell, J. H	42 45	70 55	25	T	7
Lunenburg, Worcester Co	Cunningham, Geo. A	42 35	71 43	450	B T R	12
Hinsdale, Berkshire Co	Dewhurst, Rev. E	43 27	73 7	......	B T R	10
Worcester, Worcester Co	Draper, J., M. D	42 16 17	71 48 13	528	B P T R	12
Lawrence, Essex Co	Fallon, J	42 42 13	71 10 13	143	B P T R	11
Williamstown, Berkshire Co	Hopkins, Prof. A	42 42 37	70 12 42	686	B T R	12
Topsfield, Essex Co	Merriam, S. A	42 38	70 57	......	B P T R	10
Mendon, Worcester Co	Metcalf, J. G., M. D	42 6 23	71 33 35	......	B T R	12
N. Billerica, Middlesex Co	Nason, Rev. E	42 35 9	70 16 30	......	B T	12
Georgetown, Essex Co	Nelson, S. Aug	42 42	71	......	T R	5
Cambridge, Middlesex Co	Perry, Rev. Jno. B	42 20	71 11	40	T	12
Kingstown, Plymouth Co	Newcomb, G. S	42	70 45	60	T R	11
New Bedford, Bristol Co	Rodman, S	41 39	70 56	90	B P T R	11
Amherst, Hampshire Co	Snell, Prof. E. S	42 22 17	72 34 30	267	B P T R	12
Milton, Norfolk Co	Teele, Rev. A. K	42 14 37	71 6 1	115	T R	12
MICHIGAN.						
Litchfield, Litchfield Co	Bullard, R	42	84 46	1,040	B T R	12
Otsego, Allegan Co	Chase, M., M. D	....	....	......	T	12
Ontonagon, Ontonagon Co	Ellis, Edwin, M. D	46 52	89 30	620	T	12
Adrian, Lenawee Co	Helme, Miss L. May	41 57	83 57	1,240	T R	6
Detroit, Wayne Co	Higgins, F. W	42 20	82 03	......	T R	11
Grand Rapids, Kent Co	Holmes, Dr. E. S	43	85 40	780	T	12
Macon, Lenawee Co	Howell, D	....	....	......	T R	1
Lansing, Ingham Co	Kedzie, Prof. R. C	....	....	......	B P T R	10
Olivet, Eaton Co	Kemp, Prof. A. F	46 26	84 94	968	B T R	1
Kalamazoo, Kalamazoo Co	Mapes, H. H	....	....	......	N	12
Pleasanton, Manistee Co	Millard, Jos. D	44 25	86 10	750	T R	8
Muskegon, Muskegon Co	Pattison, H. A	....	....	......	B T R	8
Alpena, Alpena Co	Paxton, J. M	45 02	83 05	574	B T R	12
Northport, Leelenaw Co	Smith, Rev. G. N	45 08	85 41	592	T R	12
Coldwater, Branch Co	Southworth, N. L	....	....	......	T R	12
Homestead, Benzie Co	Steele, Rev. G. N	44 35	86 30	......	T	2
Grand Rapids, Kent Co	Streng, L. H	....	....	......	T R	9
Monroe, Monroe Co	Whelpley, Miss F. E	41 58	83 23	590	T R	11
Central Mine, Keweenaw Co	Whittlesey, S. H	47	87 54	1,177	T R	12
Benzonia, Benzie Co	Wilson, W	44 31	86	620	T	7
Ann Arbor, Washtenaw Co	Winchell, Mrs. N. H	42 16	83 44	840	T R	8

List of meteorological stations and observers, &c., for the year 1870—Continued.

Station.	Name of observer.	North latitude.	West longitude.	Height.	Instruments.	No. months received.
MINNESOTA.		° ′ ″	° ′ ″	*Feet.*		
Afton, Washington Co	Babcock, Dr. & Mrs. B.F.	44 50	93	950	T R	7
Minneapolis, Hennepin Co	Cheney, Wm	44 48	93 10	856	B P T R	12
Madelia, Watonwan Co	Murphy, W. W	44	94 30	......	T R	12
St. Paul, Ramsey Co	Paterson, Rev. A. B	44 54 46	94 4 54	800	T R	12
White Earth Reservation, Becker Co.	Pyle, Dr. D	47 50	95	......	T	3
New Ulm, Brown Co	Roos, Chas	44 46	94 26	821	T R	12
Litchfield, Meeker Co	Wadsworth, H. L	45 12	94 45	......	T R	6
Beaver Bay, Lake Co	Wieland, C	47 12	96 19	657	T R	12
Sibley, Sibley Co	Woodbury, C.W. & C. E.	44 31	94 25	......	T R	12
Koniska, McLeod Co	Young, T. M	45 10	94 20	......	T R	11
MISSISSIPPI.						
Early Grove, Marshall Co	Abernethy, W. M	35	90	434	T R	1
Philadelphia, Neshoba Co	Bowden, L. A	32 45	89 15	550	T R	11
Near Holly Springs, Marshall Co.	Coleman, T. B	34 40	....	......	T R	7
Marion, Lauderdale Co	Florer, T. W., M. D	32 25	88 05	83	T R	4
Clinton, Hinds Co	Jackson, R. S	....	....	......	B T R	1
Near Brookhaven, Lawrence Co.	Keenan, Miss W. E. A	31 34	90 40	......	T R	12
Columbus, Lowndes Co	Lull, Jas. S	35 30	88 29	227	B T R	12
Natchez, Adams Co	McCary, W	31 34	91 24 42	......	B T R	5
Brookhaven, Lawrence Co	Moore, T. B	31 37	90 15	430	T R	7
Grenada, Yalabusha Co	Payne, John S	33 45	90	......	T R	6
Grenada, Yalabusha Co	Ringgold, R. S., M. D	33 45	90	......	T R	1
Fellowship, Jasper Co	Robinson, Rev. E. S	32	85	285	B P T R	11
MISSOURI.						
St. Joseph, Buchanan Co	Bullard, Rev. H	39 45	94 53	......	T R	6
Harrisonville, Cass Co	Christian, John	....	....	......	T R	9
Jefferson City, Cole Co	De Wyl, N	38 20	92	650	B T	12
Allentown, St. Louis Co	Fendler, Aug	38 29	90 45	482	B P T R	12
Warrensburg, Johnson Co	Hall, S. K	38 45	93 40	600	B	1
Oregon, Holt Co	Kaucher, Wm	39 58 40	95 10	1,100	B P T R	12
Cave Spring Academy, Greene Co	McCord, R. H	37 30	93 30	......	T R	1
Corning, Holt Co	Martin, Horace	40 20	95 30	......	T R	6
Bolivar, Polk Co	Race, Jas. A	37 30	93 20	1,000	T R	1
Rolla, Phelps Co	Ruggles, H	37 38	91 33	......	T R	12
Kansas City, Jackson Co	Salisbury, S. W	39 5	94 40	710	B T	11
Hematite, Jefferson Co	Smith, John M	38 11	90 37	475	T R	12
St. Louis, St. Louis Co	Stuntebeck, Rev. F. H	38 37 23	90 15	470	B P T R	12
MONTANA.						
Missoula, Missoula Co	Reinhard, J. P., and J. M. Menesinger.	46 45	113 45	3,900	T	3
Deer Lodge City, Deer Lodge Co.	Stuart, Granville	46 40	112 40	4,240	T R	12
NEBRASKA.						
Richland, Washington Co	Bowen, John S	41 22	96 12	1,350	T	3
Near Bellevue, Sarpy Co	Caldwell, Mrs. E. E	41 08	95 46	......	T R	12
Lincoln, Lancaster Co	Goodrich, G. A	40 55	96 52	1,647	T R	2
Blackbird Hills, Burt Co	Hamilton, Rev. W	42 10	96	......	T R	12
Nebraska City, Otoe Co	Pettenger, J. M., and P. Zahner.	40 42	95 45	1,225	T	12
De Soto, Washington Co	Seltz, Chas	41 50	96	975	T R	11
Newcastle, Dixon Co	Smith, L. H	43	97 20	......	T R	8
NEW HAMPSHIRE.						
Tamworth, Carroll Co	Brewster, Alfred	48 48	71 18	......	T R	12
Stratford, Coos Co	Brown, Branch	44 40	71 07	1,000	T R	12
Dunbarton, Merrimack Co	Colby, Alfred	43 06	71 35	730	T R	12
Salisbury, Merrimack Co	Couch, E. D	43 23	71 20	500	T	4
South Antrim, Hillsboro Co	Hurlin, Rev. W	....	....	......	N	12
Whitefield, Coos Co	Kidder, L. D	44 20	71 15	......	T R	12
Shelburne, Coos Co	Odell, F	44 23	71 6	700	B T	2
Concord, Merrimack Co	Wheeler, John T	43 12	71 29	550	T	4
NEW JERSEY.						
Chester Township, Burlington Co	Beans, Thomas J	39 59	74 54	......	T R	12
Haddonfield, Camden Co	Boadle, J., and J. L. Lippincott.	....	....	......	P T R	12

List of meteorological stations and observers, &c., for the year 1870—Continued.

Station.	Name of observer.	North latitude.	West longitude.	Height.	Instruments.	No. months received.
NEW JERSEY—Cont'd.		° ′ ″	° ′ ″	*Feet.*		
Paterson, Passaic Co	Brooks, William	40 55	74 10	60	T R	12
South Orange, Essex Co	Chandler, W. J., M. D.	40 44 25			P T R	4
Trenton, Mercer Co	Cook, E. R	40 14	74 46 30	60	B T R	11
Newfield, Gloucester Co	Couch, E. D	39 30	74 50	180	T	7
Lesser Cross Roads, Somerset Co	Fleming, J				T	8
New Brunswick, Middlesex Co	Hasbrouck, I. E				B P T R	5
Vineland, Cumberland Co	Ingram, J., M. D.				B P T R	12
Camden, Camden Co	Martindale, I. C				N	2
New Germantown, Hunterdon Co	Noll, A. B	42 40	74 45		B T R	12
Rio Grande, Cape May Co	Palmer, Mrs. J. R.	39 16	74 42		T R	12
Greenwich, Cumberland Co	Sheppard, Miss R. C	39 20	75 25	30	B P T R	12
Newark, Essex Co	Whitehead, W. A.	40 45	74 10	35	B T R	12
NEW YORK.						
Ardenia, Philipstown, Putnam Co	Arden, T. B.	40 20 22	73 53 22	180	T R	12
Milo, Yates Co	Baker, G. D	42 30		868	T R	12
South Trenton, Oneida Co	Barrows, Captain S	43 10	74 56	835	T R	12
Palermo, Oswego Co	Bartlett, E. B	43 26	77 26	327	T R	11
Minaville, Montgomery Co	Bussing, J. W	42 54	74 15		T R	12
Lockport, Niagara Co	Clark, B. W	43 9	79		T R	7
Fort Edward, Washington Co	Cooley, Prof. J. S	43 13	73 42		B T	5
Little Genesee, Allegany Co	Edwards, D	42 0 15	78 20	1,500	B T R	12
Rochester, Monroe Co	Fiske, W. M. L., M. D	43 8	77 51	525	B T R	2
Bannerville, Schoharie Co	France, G. S	42 38		1,200	T R	4
Newburgh, Orange Co	Gardiner, J. H	41 30 53	74 1	96	B T R	11
Depauville, Jefferson Co	Haas, H	44 10	76 3	350	T R	12
Hudson, Columbia Co	Hachenberg, G. P., M. D	42 14	73 46		P T R	1
Near Kingston, on the Hudson, Ulster Co.	Hendricks, D. B	41 50	74 2	150	T R	12
Nichols, Tioga Co	Howell, R	42	76 32		T	12
North Argyle, Washington Co	Hunt, G. W	43 18	72 29	290	B T R	1
South Hartford, Washington Co.	Ingalsbe, G. M	43 18	73 21 3	400	T R	12
Buffalo, Erie Co	Ives, W	42 50	78 56	600	B T R	12
Newark Valley, Tioga Co	Johnson, Rev. S. W				T R	12
New York, New York Co	Joy, Prof. C. A	40 43	74 5	100	B P T R	3
Cooperstown, Otsego Co	Keese, G. Pomeroy	42 50	74 54	1,200	T R	12
Flatbush, Kings Co	Mack, E. T	40 37 17	74 1 33	54	B T R	12
Brooklyn, Kings Co	Maille, I. P	40 40	73 56	125	B P T R	7
Oswego, Oswego Co	Malcolm, W. S	43 28	76 30	250	B T R	12
New York, New York Co	Marsh, Mrs. M. M	40 42	74 1 8	25	B P T R	6
Rochester, Monroe Co	Mathews, H. W	43 8	77 51	525	B P T R	8
Brooklyn, Kings Co	Meeker, J. S				R	1
Leyden, Lewis Co	Merriam, C. C	43 32 30	75 24		B T R	6
Farmingdale, Queens Co	Merritt, John C	40 40 40	73 30	102	N	11
Throg's Neck, Westchester Co	Morris, Miss E	40 49 15	73 48 45	43½	T	12
New York, New York Co	Morris, Prof. O. W	40 50 25	73 56 30	165	B P T R	12
New York, New York Co	Naval Hospital	40 41 30	74 1	56	B T R	12
Central Park, New York Co	Observatory	40 45 58	73 57 58	97	B P T R	12
North Volney, Oswego Co	Partrick, J. M				T	12
Sloansville, Schoharie Co	Potter, G. W	42 41	74 31		T R	1
Gouverneur, St. Lawrence Co	Russell, C. H	44 19	75 29		B T R	11
Brookhaven, Suffolk Co	Smith, E. A., and daughters.	40 49	72 36	13	T R	12
Cazenovia, Madison Co	Soule, Prof. W	42 55	75 46	1,260	B T	12
Oneida, Madison Co	Spooner, Dr. S	43 4	75 50	500	T R	12
Caldwell, Warren Co	Strong, A. M	43 24	72 46	300	B P T R	2
Luzerne, Warren Co	Strong, A. M				B P T R	4
Vassar College, Poughkeepsie, Dutchess Co.	Swallow, Miss	41 40 50	42 55 33		B T R	2
Waterburgh, Tompkins Co	Trowbridge, D	42 30	77 15	800	T R	11
Utica, Oneida Co	Williams, J. Gilbert	43 10	74 57	518	T R	12
White Plains, Westchester Co	Willis, O. R., and daughters.	41 5	73 40	273	T	12
North Hammond, St. Lawrence Co	Wooster, C. A	44 30	75 41		B T R	12
Houseville, Lewis Co	Yale, Walter D	43 40	75 32		T R	10
NORTH CAROLINA.						
Statesville, Iredell Co	Allison, T. P	35 30	80 30		T R	12
Asheville, Buncombe Co	Aston, Edw. J				T R	12
Goldsboro, Wayne Co	Adams, Prof. E. W	35 20	77 51	102	T R	12
Warrenton, Warren Co	Foote, H. A	36 15	78 15		T R	12
Asheville, Buncombe Co	Hardy, J. F. E., M. D	35 30	82 31	2,250	B T	12
Oxford, Granville Co	Hicks, W. R., M. D	36 23	78 14		T R	11

List of meteorological stations and observers, &c., for the year 1870—Continued.

Station.	Name of observer.	North latitude.	West longitude.	Height.	Instruments.	No. months received.
NORTH CAROLINA—Cont'd.		° ′ ″	° ′ ″	*Feet.*		
Attaway Hill, Stanly Co	Kron, F. J	35 25	80	850	T R	12
Near Raleigh, Wake Co	Murdock, W. H	36 37	78 45	385	R	1
Chapel Hill, Orange Co	Patrick, Prof. D. S				T	5
Kenansville, Duplin Co	Sprunt, Rev. J. M	34 53	75 3	40	B T	5
OHIO.						
Bellefontaine, Logan Co	Barringer, W	40 23	83 45	1,169	T R	6
New Lisbon, Columbiana Co	Benner, J. F., and W. R. Smiley	40 45	80 45	961	B P T R	3
Quaker Ridge, Morgan Co	Bingman, T. J	40 30	82	555	T R	8
North Fairfield, Huron Co	Burras, O	41 8	82 40	660	T R	12
Bowling Green, Wood Co	Clarke, J	41 22	83 40	700	T R	10
Gambier, Knox Co	Compton, F., and others	40 20 30		1,000	B P T R	11
Bethel, Clermont Co	Crane, G. W	39	84	555	T R	12
Steubenville, Jefferson Co	Doyle, Joseph B	40 45	80 47		B T R	12
Little Mountain, Geauga Co	Ferriss, E. J	41 38	81 16	600	B P T R	12
College Hill, Hamilton Co	Hammitt, John W	39 19	70 14 45	800	T R	12
Cincinnati, Hamilton Co	Harper, G. W	39 6	84 29		B T R	10
Westerville, Franklin Co	Haywood, Prof. J	40 4	83		B P T R	12
Springfield, Clark Co	Hachenberg, G. P., M. D				B P T R	5
Oberlin, Loraine Co	Herrick, L	41 20	81 15	800	T R	11
Wooster, Wayne Co	Hoover, W	40 49	81 55	872	T R	2
Kelley's Island, Erie Co	Huntingdon, G. C	41 35 44	82 42 32	587	B T R	12
Cleveland, Cuyahoga Co	Hyde, G. A	41 30	80 40		B T R	12
Edgerton, Williams Co	Knight, A. B	41 32	83 45	831	T R	2
Oxford, Butler Co	McFarland, Prof. R. W	39 30	84 46	950	B P T R	12
Ripley, Huron Co	Marsh, Mrs. M. M	41	82 30	965	B P T R	5
Hillsboro, Highland Co	Mathews, J. McD	39 13			B P T R	12
Carthagena, Mercer Co	Muller, Dr. R	40 28	84 33		B P T R	4
North Bass Island, Ottawa Co	Morton, George R., M. D	41 36	82 41 53			12
Gilmore, Tuscarawas Co	Moore, S. M	40 18	81 18	1,180	T	5
Margaretta Township, Erie Co	Neill, Thomas	41 27	82 46		B P T R	12
Jacksonburg, Butler Co	Owsley, J. B., M. D	39 30	84 17	1,152	T R	12
Cincinnati, Hamilton Co	Phillips, R. C				B T R	12
Salem, Columbiana Co	Pollock, Rev. J. E	40 54	81	950	T R	12
Gallipolis, Gallia Co	Rodgers, Alexander P	39	82	600	T R	8
Kenton, Hardin Co	Smith, C. H., M. D			543	T R	12
Adams Mills, Muskingum Co	Stillwell, C. A	40 5	82	900	P T R	7
Milnersville, Guernsey Co	Thompson, Rev. D	40 10	81 45		T R	4
New Birmingham, Guernsey Co	Thompson, Rev. D				T R	8
Toledo, Lucas Co	Trembley, J. B., M. D	41 38	83 30		B T R	6
Mount Auburn, Hamilton Co	White, J. H			1,000	B P T R	12
Williamsport, Pickaway Co	Wilkinson, J. R	39 37 4	83 7 30		T R	6
Urbana, Champaign Co	Williams, Prof. M. G	40 6	83 43	1,015	B T R	12
Wooster, Wayne Co	Winger, M	40 48 47	81 55 37	872	T R	6
OREGON.						
Portland, Multnomah Co	Gilliland, S. W., & J. S. Ried	45 31 15	122 26 6	45	B P T R	11
Eola, Polk Co	Pierce, Thomas	44 57	123 05	500	T R	12
Astoria, Clatsop Co	Wilson, Louis	46 11 28	123 49 32	52	B P T R	6
PENNSYLVANIA.						
Pittsburg, Alleghany Co	Albree, C				T R	10
Tioga, Tioga Co	Bentley, E. T	42	77	1,000	T R	12
Carlisle, Cumberland Co	Cook, Dr. W. H				B T R	12
Plymouth Meeting, Montgomery Co.	Corson, M. H	40 6			B P T R	12
Ashland, Schuylkill Co	Curtis, A				T	8
Pocopson, Chester Co	Darlington, F	39 54	75 37	218	T R	12
Dyberry, Wayne Co	Day, Theodore	41 36	75 19		T R	8
Harrisburg, Dauphin Co	Egle, Dr. W. H	40 16	76 15		B T R	7
Near Pennsville, Clearfield Co	Fenton, E	41	78 40	1,400	B T R	12
Blooming Grove, Pike Co	Grathwohl, John	41 30	75		T R	11
Fallsington, Bucks Co	Hance, E	40 12	74 48	30	B T R	12
Tamaqua, Schuylkill Co	Haworth, J	40 45	76	700	T	10
Hazleton, Luzerne Co	Haworth, J			1,800	T	1
Mount Joy, Lancaster Co	Hoffer, J. R., M. D	40 8	76 32		B T	8
Ashland, Schuylkill Co	Honeyman, Rev. W. E	40 51	76 20	1,005	T R	5
Brownsville, Fayette Co	Hubbs, J. Allen	40	80		T R	12
Lewisburg, Union Co	James, Prof. C. S	40 58	76 58		B P T R	12

List of meteorological stations and observers, &c., for the year 1870—Continued.

Station.	Name of observer.	North latitude.	West longitude.	Height.	Instruments.	No. months received.
PENNSYLVANIA—Cont'd.		° ′ ″	° ′ ″	*Feet.*		
Whitehall, Lehigh Co	Kohler, E	40 44	75 28	450	T R	11
Philadelphia, Philadelphia Co	Kirkpatrick, J. A	39 57	75 11	60	B P T R	12
Newcastle, Lawrence Co	McConnell, E. M	40	80 12		T R	12
Westchester, Chester Co	Martin, Dr. George	39 57 31	75 36 3	460	B P T R	11
Germantown, Philadelphia Co	Meehan, T				T	12
Williamsport, Lycoming Co	Moyer, H. C	41 19	81 39	533	T	2
Philadelphia, Philadelphia Co	Naval Hospital	39 56	75 10	36	B T R	12
Johnstown, Cambria Co	Peelor, D			1,200	B P T R	12
Reading, Berks Co	Raser, J. Heyl	40 20	75 57		T R	12
Greencastle, Franklin Co	Rhode, S. W	39 45	77 30	650	T R	3
Abington, Luzerne Co	Sisson, R	41 30	75 45		T R	12
Cannonsburg, Washington Co	Smith, Dr. Wm	40 16 41	80 10	850	B T R	12
Mooreland, Montgomery Co	Spencer, Miss Anna	40	75 11	250	B P T R	12
Ephrata, Lancaster Co	Spera, W. H	40 12	76 15		P T R	12
Salem, Wayne Co	Stocker, J. D	41 30	75 30		T R	12
Connellsville, Fayette Co	Taylor, John	40	79 36		T R	12
Beaver, Beaver Co	Taylor, Rev. R. T	40 43	80 23		T R	12
Franklin, Venango Co	Tolman, Rev. M. A	41 24	79 51	980	T R	12
Germantown, Philadelphia Co	Turner E., C. E				B T R	12
Fountain Dale, Adams Co	Walker, S. C	39 44	77 18		P T R	12
RHODE ISLAND.						
Newport, Newport Co	Barber, W. A	41 28 22	71 21 14	25	T R	7
Newport, Newport Co	Crandell, Wm. H	41 28 22	71 21 14	25	T R	5
SOUTH CAROLINA.						
Aiken, Barnwell Co	Cornish, Rev. J. H	33 32	81 34	565	B T R	12
Evergreen, Anderson Co	Earle, E. S	34 30	82 50		T R	4
Bluffton, Beaufort Co	Guerard, S. St. J., M. D	32 10	81		T R	12
Gowdeysville, Union Co	Petty, Chas	34 50	81 36	600	T R	12
Fort Hill, York Co	Springs, R. A., jr	35	81		T	4
TENNESSEE.						
Lookout Mountain Educational Institute, Hamilton Co.	Bancroft, Rev. C. F. P	35	81 5	2,200	B T	12
Austin, Wilson Co	Calhoun, P. B				T R	10
Greeneville, Greene Co	Doak, S. S. & W. S	36 5	82 51		T R	6
Lagrange, Fayette Co	Franklin, W. E	35 7 30	89 15 25	462	T R	6
Memphis, Shelby Co	Goldsmith, E	35 8	90	262	B P T R	3
Trenton, Gibson Co	Grigsby, Wm. T	36	89		T R	10
Elizabethtown, Carter Co	Lewis, C. H	36 25	82 15	1,500	T R	12
Knoxville, Knox Co	Payne, Prof. J. K	36	84	990	B P T R	9
Clarksville, Montgomery Co	Stewart, Prof. W	36 29	87 13	481	B P T R	12
McMinnville, Warren Co	Wright, T. P	35 42	85 57	1,000	T	8
TEXAS.						
Clarksville, Red River Co	Anderson, Rev. J	33 40			T	7
Houston, Harris Co	Baxter, Miss E	29 50	95 30	50	T	6
Palestine, Anderson Co	Brooks, N. S	31 40	95 35	480	T R	8
Bremond, Robertson Co	Combs, B				R	5
Bluff P. O., Fayette Co	Fietsam, J	30	97	189	T R	7
Near Gilmer, Upshur Co	Glasco, J. M	32 46	94 51	950	T R	12
Blue Branch, Burleson Co	Goode, W. H	30 27	97 26	600	T R	6
Lavaca, Calhoun Co	Heaton, L. D	28 30	96 40	17	T R	8
San Antonio, Bexar Co	Pettersen, F	29 28	98 24	564	P T R	5
Oakland, Texas Co	Simpson, F	29 65	96		T R	11
Austin, Travis Co	Van Nostrand, J	30 29	97 46	650	T R	12
Blue Branch, Burleson Co	Wade, F. S	30 25	97 26	600	T R	9
Sand Fly, Burleson Co	Wade, F. S				T R	1
Clinton, De Witt Co	White, Dr. A. C	29	97 37		T R	12
Lockhart, Caldwell Co	Woodruff, L				T R	7
UTAH.						
Coalville, Summit Co	Bullock, T	40	111	5,600	T	9
St. George, Washington Co	Johnson, C	37 11	114		T	3
Harrisburg, Washington Co	Lewis, James				R	7
Salt Lake City, Salt Lake Co	Phelps, W. W	40 45	111 26		T	10

List of meteorological stations and observers, &c., for the year 1870—Continued.

Station.	Name of observer.	North latitude.	West longitude.	Height.	Instruments.	No. months received.
VERMONT.		° ′ ″	° ′ ″	Feet.		
Panton, Addison Co	Barto, D. C. and M. E	44	74	......	T R	12
Newport, Orleans Co	Currier, J. M	44 55	72 20	750	T R	11
Lunenburg, Essex Co	Cutting, H. A	44 28	71 41	1,124	B P T R	12
Woodstock, Windsor Co	Doten, H., & L. A. Miller.	43 36	72 35	698	T R	12
South Troy, Orleans Co	Kennedy, J. C	....	....	......	T R	1
Randolph, Orange Co	Paine, C. S	43 55	73 36	650	T R	12
Middlebury, Addison Co	Sheldon, H. A	43 59	73 10	398	B P T R	6
Craftsbury, Orleans Co	Wild, Rev. E. P	44 40	72 30	1,100	T R	12
Castleton, Rutland Co	Williams, Rev. R. G	....	....	......	B P T R	12
Charlotte, Chittenden Co	Wing, Minerva E	....	....	......	T R	12
VIRGINIA.						
Mulberry Hill, Isle of Wight Co.	Binford, R	36 50	76 50	100	T R	7
Vienna, Fairfax Co	Bowman, J. B. and G. A.	38 53 39	77 11	400	T R	5
Wytheville, Wythe Co	Brown, Rev. James A	36 55	81 4	2,400	B T R	12
Lexington, Rockbridge Co	Campbell, Prof. J. L	....	....	......	B T R	3
Staunton, Augusta Co	Covell, J. C	38 8	78 46	1,261	B P T R	12
Mt. Vernon Township, Fairfax Co	Gillingham, C	38 40	77 15	150	B T R	2
Cottage Home, Surry Co	Jones, B. W	37 10	76 46	......	T R	11
Mechanicsville, Fauquier Co	Martin, W. A	38 50	78	......	T R	12
Near Lynchburg, Bedford Co	Meriwether, C. I	37 18	79 19	800	T	12
Near Johnsontown, Northampton Co.	Moore, C. R	37 22	75 46	40	B T R	12
Norfolk, Norfolk Co	Naval Hospital	36 25	76 25	25	B T R	12
Near Markham Station, Fauquier Co.	Payne, L. E	39	78	......	T R	2
Near Lexington, Rockbridge Co.	Ruffner, W. H	37 4	79 22	1,000	T R	8
Hampton, Elizabeth City Co	Sherman, J. M	37 5	76 20	5	T R	12
Snowville, Pulaski Co	Stalnaker, J. W., M. D	37	80	1,800	T R	6
Powhatan Hill, King George Co.	Tayloe, E. T	....	....	60	T R	12
Near Fairfax C. H., Fairfax Co.	Thrift, Miss L. R	38 53 39	77 21	500	T R	7
Near Piedmont, Fauquier Co	Williams, F	38 50	78	900	T R	12
Vienna, Fairfax Co	Williams, H. C	38 53	77 12	400	B P T R	12
WASHINGTON TERRITORY.						
Cathlamet, Waukiakum Co	McCall, C	46 15	123 30	45	T	7
Tatoosh Island Light-House, Clallam Co.	Sampson, Alex. M	....	....	......	T R	11
Walla-Walla, Walla-Walla Co	Simmons, A. H	46 5	118 52	930	T R	1
Lake Washington, King Co	Whitworth, Mr. and Mrs. J. E.	47	....	......	T	7
WEST VIRGINIA.						
Romney, Hampshire Co	McDowell, W. H	....	....	......	T	3
Weston, Lewis Co	Owen, Benjamin	39	....	......	T	6
Ashland, Cabell Co	Roffe, C. L	38 30	82 16	600	T R	7
WISCONSIN.						
Embarrass, Waupaca Co	Breed, E. E	44 51	88 37 30	......	T R	11
Rocky Run, Columbia Co	Curtis, W. W	43 26	89 19	......	T R	12
Madison, Dane Co	Daniells, Prof. W. W	43 5	89 24	1,068	B P T R	12
Holland, Sheboygan Co	De Lyser, John	43 36	87 54	670	T	11
New Lisbon, Juneau Co	Dungan, J. L	43 45	90	......	T	6
Appleton, Outagamie Co	Foye, Prof. J. C	44 10	88 35	800	B T	5
Milwaukee, Milwaukee Co	Lapham, I. A., LL. D	43 3	87 56 10	604	B P T R	12
Manitowoc, Manitowoc Co	Lüps, Jacob	44 7	87 45	658	B T R	12
Waupaca, Waupaca Co	Mead, H. C	44 20	89 11	900	T	1
Plymouth, Sheboygan Co	Moeller, G	43 44	88 7	......	B T R	3
Mosinee, Marathon Co	O'Donoghoe, J	45	89 30	750	T R	12
Tunnel City, Monroe Co	Pegler, Rev. G	43 45	91 40	700	T R	8
Edgerton, Rock Co	Shintz, H. J	42 30	89	1,700	T R	12
Wautoma, Waushara Co	Spaulding, J	44	89 20	1,200	R	7
Bayfield, Bayfield Co	Tate, Andrew	....	....	......	T	12
Baraboo, Sauk Co	Waite, M. C	43 27 1	89 45 1	920	T R	12
Bloomfield, Wabash Co	Whiting, W. H	....	....	600	T R	12
Sturgeon Bay, Door Co	Wright, R. M	45	87 30	647	T R	11

DEATHS OF OBSERVERS.

H. A. Sheldon, Middlebury, Vermont.
G. Moeller, Plymouth, Wisconsin, March 14, 1870.

COLLEGES AND OTHER INSTITUTIONS FROM WHICH METEOROLOGICAL REGISTERS WERE RECEIVED DURING THE YEAR 1870, INCLUDED IN THE PRECEDING LIST.

State.	Institution.	Location.
Nova Scotia	Acadia College	Wolfville.
Alabama	Greene Springs School	Havana.
California	Pacific Methodist College	Vacaville.
Connecticut	Wesleyan University	Middletown.
Georgia	Mercer University	Penfield.
Illinois	Lombard University	Galesburg.
	Northwestern University	Evanston.
Indiana	City Hospital	Indianapolis.
Iowa	Cornell College	Mount Vernon.
	Iowa State University	Iowa City.
Kansas	Agricultural College	Manhattan.
	State University	Lawrence.
Maryland	Mount St. Mary's College	Emmittsburg.
	Woodstock College	Baltimore County.
Massachusetts	Amherst College	Amherst.
	State Lunatic Hospital	Worcester.
	Williams College	Williamstown.
Michigan	Agricultural College	Lansing.
	Olivet College	Olivet.
Mississippi	Mississippi College	Clinton.
Missouri	St. Louis University	St. Louis.
New Hampshire	St. Paul's School	Concord.
New York	Columbia College	New York.
	Erasmus Hall Academy	Flatbush.
	Oneida Conference Seminary	Cazenovia.
	Rutgers Female College	New York.
	Vassar College	Poughkeepsie.
North Carolina	Webster Institute	Kenansville.
	State University	Chapel Hill.
Ohio	Kenyon College	Gambier.
	Miami University	Oxford.
	Mount Auburn Young Ladies' Institute	Mount Auburn.
	Otterbein University	Westerville.
	Theological Seminary	Carthagena.
	Urbana University	Urbana.
	Woodward High School	Cincinnati.
Pennsylvania	Beaver Seminary	Beaver.
	Jefferson College	Canonsburg.
	Lewisburg University	Lewisburg.
Tennessee	East Tennessee University	Knoxville.
	Lookout Mountain Educational Institute	Hamilton County.
	Stewart College	Clarksville.
	Tusculum College	Greeneville.
Texas	Institution for Deaf and Dumb	Austin.
Vermont	Normal School	Castleton.
Virginia	Washington College	Lexington.
	Institution for Deaf, Dumb and Blind	Staunton.
Wisconsin	Lawrence University	Appleton.
	State University	Madison.

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Barnes, Dr. G. W.—Summary of meteorological observations at Grass Valley, California, during the months of June, July, August, September, and October, 1870.

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Berendt, Dr. H.—Newspaper cuttings on the climate of Belize, British Honduras.

Board of Commissioners, Central Park, New York.—Thirteenth annual report, contains general meteorological observations for 1869, and description of observatory.

Boardman, G. A.—Notes on the storm of October 4th and 5th, 1869, at Milltown, Maine.

Boerner, C. G.—Paths of meteors observed during the auroral display of October 24, 1870.

Bruhns, Dr. C.—Meteorologische Beobachtungen, angestellt auf der Leipziger Universitäts-Sternwarte im Jahre 1868. 18vo, 30 pages, 1 Table.

Bullock, T.—Summary of temperature observations at Coalville, Utah, for the year 1869.

Carpenter, P. P., Montreal, Canada.—Account of aurora observed during September, 1870, at Montreal, by Thomas McGinn, (newspaper slip.)

Cazalis, Dr. F.—"Le messager agricole," Montpellier, France, December, 1867, containing meteorological observations made at Montpellier, Departement de Herault.

Cockburn, H.—Notes on British Honduras, (containing meteorological records for Belize, rain-fall from 1862 to 1868 inclusive.)

Crocker, Allen, Burlington, Kansas.—Diagram and description of remarkable halo seen February 5, 1870.

Curtis, A.—Meteorological summary for 1869 at Ashland, Schuylkill County, Pennsylvania.

Daguin, M.—Résumé des observations meteorologiques faites à l'observatoire de Toulouse pendant l'année 1867–'68, par M. Daguin. 8vo, 11 pages; 1868–'69, 8vo, 4 pages.

Daniels, Wm.—Record of weather during the month of July, 1870, at Peru, Miami County, Indiana.

Deem, D.—Diagram of thermometrical and barometrical curves, and snow and rain-fall, for February, 1869, at Knightstown, Indiana. The same for November, 1869, at Mount Hope, Indiana.

Dodd, Professor C. M.—Record of anemometer (Robinson's) at the Indiana State University, during November, 1869.

Dudley, T.—Account of halo seen at Decatur, Illinois, February 5, 1870.

Ewing, C. G.—Meteorological observations at San Francisco, California, during part of the year 1870. (Newspaper slips from Daily Alta California.)

Foster, Captain R. W.—Notes made on a passage through the Straits of Magellan, in the steamship City of Pittsburgh, in the year 1852.

Foster, Capt. R. W., New Orleans.—Journal of the voyage of the steamship Alabama from New Orleans to Vera Cruz in December, 1850.

French, J. B., Agent.—Rain and snow fall record kept by the W. L. C. & W. Manufacturing Company at Laconia, Bristol, and other places in New Hampshire, during 1870.

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Government of Victoria, Australia.—Discussion of the meteorological and magnetical observations made at the Flagstaff Observatory, Melbourne, during the years 1858–'63, by Geo. Neumayer, Ph. D. Mannheim, 1867. 4to, 202 pages.

Green, H. A.—Record of weather at Atco, New Jersey, during 1870.

Record of thermometer at Atco, New Jersey, during November and December, 1869.

Haidinger, W. Ritter von.—Ueber das Regenbogen-Phänomen am 28. Juli, 1861. 8vo, 6 pages.

On the phenomena of light, heat, and sound accompanying the fall of meteorites. By W. Ritter von Haidinger. (From Proc. R. S., No. 107, 1868.) 8vo, 6 pages.

Howland, L., United States Consul.—Meteorological observations for the month of May, 1870, at the University of Valencia. (Printed slip.)

James, I. W.—Summary of observations at Marengo, Illinois, during 1870.

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Ueber die tägliche und jährliche Periode der relativen Feuchtigkeit in Wien. Von Hans Wittek. 8vo, 13 pages, 2 Tables.

Ueber die jährliche Vertheilung der Gewittertage, nach den Beobachtungen an den meteorologischen Stationen in Oesterreich und Ungarn. Von Dr. C. Jelinek. 8vo, 9 pages.

Jewell, J. Grey, M. D., United States Consul Singapore.—Meteorological observations at Singapore, British East Indies, during the months of May, June, July, August, September, October, November, and December, 1869. By H. Q. Randell, colonial surgeon.

K. K. Centralanstalt für Meteorologie und Erdmagnetismus.—Beobachtungen an der K. K. Centralanstalt für Meteorologie und Erdmagnetismus.

K. K. Sternwarte in Krakau.—Mittlere Temperatur zu Krakau, nach 40-jährigen Beobachtungen, 1826–1865. Von Dr. F. Karlinski. 4to, 14 pages, 1 diagram.

K. K. Sternwarte, Prag.—Magnetische und meteorologische Beobachtungen auf der K. K. Sternwarte zu Prag, im Jahre 1869. 4to, 170 pages.

Knapp, Geo. C.—Meteorological register from January to April, 1869, at Billis, Asia.

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Latham, Dr. H. L.—Notes on the climate of Laramie Plains, Wyoming Territory.

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Macgregor, C. J., M. A.—On the climatology of Stratford, Ontario. 8vo, 4 pages.

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Mapes, H. H.—Monthly manuscript notes on the weather at Oshtemo, Kalamazoo, and other points in Michigan.

Merriam, C. L.—Meteorological comparisons from records kept at Locust Grove, Leyden, Lewis County, New York.

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Weather reports from July 1, 1868, to June 30, 1870. 3 volumes, folio; 6 parts unbound.

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Meteorological Office, Calcutta.—Report of the meteorological reporter to the government of Bengal. Meteorological abstract for the year 1869. By H. F. Blandford, meteorological reporter. Large 8vo, 108 pages.

Meteorological Society, London.—Proceedings.

Miller, Rev. Jas. N.—The true direction and velocity of the wind observed from ships while sailing. By Rev. J. N. Miller. 8vo, 18 pages.

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Moss, G. B.—Monthly manuscript summaries of meteorological observations at Belvidere, Illinois.

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Naturforschende Gesellschaft in Emden.—Das Gesetz der Winde, abgeleitet aus dem Auftreten derselben über Nordwest-Europa. Von Dr. M. A. F. Prestel. Mit einer Karte. 4to, 26 pages.

Nelson, S. A.—Newspaper cuttings in reference to certain storms in Massachusetts in the year 1870.

Newton, E. H.—Range of thermometer at Mount Carmel, Covington County, Mississippi, latitude 31° 34′, longitude 90° 20′ 15″, during the months of January and February, 1870.

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Observatorio Marina de San Fernando.—Anales, seccion e observaciones meteorolojicas, 1870. 4to, 32 pages.

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Paine, Dr. H. M., Albany, New York.—Newspaper slips giving accounts of meteorological phenomena.

Parvin, Professor T. S.—Meteorological observations for the year 1869. (Printed slips.)

Peelor, D.—Records kept by self-registering barometer at Johnstown, Cambria County, Pennsylvania. Also various notes on meteorological phenomena, newspaper slips, &c.

Pettersen, F.—Record of weather during the years 1868, 1869, and 1870, at San Antonio, Texas.

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Prestel, Dr.—Der Sturmwarner und Wetteranzeiger, ein nach wissenschaftlichen Grundsätzen ausgeführtes und durch Beobachtungen und Erfahrung bewahrtes Instrument zu Vorherbestimmung von Sturm und Wetter. Von Dr. M. A. F. Prestel. 8vo, 55 pages, 2 Tables.

R. Accademia delle Scienze di Torino.—Bolletino meteorologico ed

astronomico del Regio Osservatorio dell' Università di Torino. Anno IV. 1869. Oblong 4to, 43 pages.

Radcliffe Observatory.—Results of astronomical and meteorological observations, 1867. Oxford, 1870. 8vo, 340 pages.

Rikatcheff, M.—Marche diurne de la température a Barnaul et a Nertchinsk; par M. Rikatcheff. 4to, 23 pages.

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Sawyer, H., United States Consul.—Meteorological observations at Paramaribo during the year 1869. (Newspaper slip.)

Scottish Meteorological Society.—Journal of the Scottish Meteorological Society.

Sheppard, Smiley.—Monthly manuscript reports of the weather at Hennepin, Illinois.

Simmons, A. H.—Photograph showing effect of southwest wind in January, at Walla-Walla, Washington Territory, in the valley of the Upper Columbia.

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Strong, A. M.—Register of meteorological observations at Magnolia, Florida, for April, 1870.

Weather record kept at St. Augustine and Jacksonville, Florida, during the months of December, 1869, and January, February, and March, 1870, by A. M. Strong and Judge Ellwood, of Iowa. Barometer record at Magnolia by Mr. Trott.

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Trembley, Dr. J. B.—Annual meteorological synopsis for 1869, at Toledo, Ohio. 8vo, 18 pages.

Università di Torino.—Bolletino meteorologico ed astronomico del Regio Osservatorio dell' Università di Torino. Anno IV. 1869. Oblong 4to, 85 pages. Anno III. 1868. Oblong 4to, 20 pages.

Universitäts-Sternwarte, Leipsic.—Uebersicht der Resultate aus den meteorologischen Beobachtungen, angestellt auf den königlich-sächsischen Stationen. 4to, 42 pages.

University of Chile.—Observaciones meteorolojicas, hechas en el observatorio meteorolojica de Santiago, i en el Faro de Valparaiso, en el año de 1866. Por José Vergara. 8vo, 63 pages. 1867. 8vo, 62 pages. 1868. 8vo, 60 pages.

Datos recajidos sobre el terremoto i las ajitaciones del mar, del 13 de Agosto de 1868. Comunicacion de D. Ignacio Domeyko a la faculdad de ciencias fisicas i matematicas en su sesion del 15 de Noviembre del mismo año. Santiago, 1869. Large 8vo, 43 pages.

Useful Knowledge Society, Macclesfield.—Meteorological observations taken at the Useful Knowledge Society rooms, Macclesfield, England. (Printed slips from 1860–'69, inclusive.)

Videnskabsselskabet, Christiania.—Storm-Atlas, udgivet med Bestand af Videnskabsselskabet, Christiania, af H. Mohn. Large folio.

Webster, W. Prentiss, United States Consul General, Frankfurt am Main.—Notes on earthquake felt in Germany during the months of October and November, 1869. (Through the Department of State.)

Whitcomb, G.—Meteorological report for 1869, by Adam Miller, at East Prairie, Mississippi County, Missouri.

Williams, Rev. R. G.—Hourly observations of barometer, psychrometer, and thermometer, together with observations on magnetic variation. (In addition to regular monthly observations on Smithsonian blanks.)

Wilson, L.—Summary of meteorological observations at Astoria, Oregon, for the years 1866–'70. Rain-fall from 1856–'70, inclusive. Monthly means.

Wing, Miss M. E.—Manuscript notes on the weather and meteorological phenomena at West Charlotte, Vermont.

Wislizenus, Dr. A.—Meteorological observations at St. Louis, Missouri, during November and December, 1869; together with the records of atmospheric electricity, &c., from 1861–'69, inclusive.

Zantedeschi, Professor F.—La meteorologia del globo studiata a diversi altitudini da terra. 8vo, 11 pages.

Zentralnaia Fisicheskaia Observatoria, St. Petersburg.—Repertorium für Meteorologie, herausgegeben von der K. Akademie der Wissenschaften; redigirt von Dr. H. Wild. Band I, Heft I. 4to, 242 pages, 5 plates.

Vorschläge betreffend die Reorganisation des meteorologischen Beobachtungs-Systemes in Russland. Bericht einer Commission der Akademie. 8vo, 24 pages.

REPORT OF THE EXECUTIVE COMMITTEE.

The Executive Committee of the Board of Regents respectfully submit the following statement as their report in relation to the funds of the Institution, the receipts and expenditures for the year 1870, and the estimates for the year 1871.

Statement of the fund at the beginning of the year 1871.

The amount originally received as the bequest of James Smithson, of England, deposited in the Treasury of the United States, in accordance with act of Congress of August 10, 1846	$515,169 00
The residuary legacy of Smithson received in 1865, deposited in the Treasury of the United States, in accordance with the act of Congress of February 8, 1867	26,210 63
Total bequest of Smithson	541,379 63
Amount deposited in the Treasury of the United States, as authorized by act of Congress of February 8, 1867, derived from savings of income and increase in value of investments	108,620 37
Total permanent Smithson fund in the Treasury of the United States, bearing interest at 6 per cent., payable semi-annually in gold	650,000 00
In addition to the above there remains of the extra fund derived from savings, &c., in Virginia State registered 6 per cent. bonds, at par value, $72,760, now valued at	48,000 00
Total investments	698,000 00
Balance on hand January, 1871, of uninvested funds	21,477 81
Total of the Smithson fund, January, 1871	719,477 81

Receipts for 1870.

Interest for 1870 on $650,000, at 6 per cent. in gold	$39,000 00
Premium on $39,000 gold, at $11\frac{3}{4}$ and $10\frac{5}{8}$ per cent.	4,363 12
Cash from a friend of science, in aid of publications	1,200 00
Sale of publications	360 52
Sale of useless materials	64 87
Repayment of expenses of explorations	68 40
Repayment of freight and postage	432 47
Total receipts for the year	45,489 38

Expenditures for 1870.

Building and furniture	$4,843 13	
General expenses	14,840 65	
Publications and researches	15,873 22	
Museum and exchanges	9,424 22	
Total expenditures for the year		44,981 22
Balance		508 16
Besides this balance of $508 16, there was a balance of $20,969 65 in bank, at the beginning of 1870, which makes the total uninvested and available balance mentioned in the general statement of		$21,477 81

In addition to the receipts mentioned above, the Institution received from and accounted to the Interior Department for $5,024, being part of the $10,000 appropriated by Congress for the preservation and care during the year ending June 30, 1871, of the specimens collected by various exploring expeditions. This sum is not included in the account of expenditures.

Statement in detail of expenditures—1870.

BUILDING.

For reconstruction of parts of building	$860 12	
For general repairs of building	3,852 81	
For furniture and fixtures, cases, carpets, stoves, &c	130 20	
		$4,843 13

GENERAL EXPENSES.

For meetings of the Board of Regents	$178 25	
For lighting the building	355 42	
For warming the building	1,566 22	
For postage	770 98	
For stationery	829 19	
For printing blanks, circulars, receipts, &c	389 13	
For tools, materials for cleaning and incidentals	478 16	
For salaries of Secretary, clerks, and assistants	10,273 30	
		14,840 65

PUBLICATIONS AND RESEARCHES.

For publishing Smithsonian contributions, 4to.	$6,986 57	
For publishing miscellaneous collections, 8vo..	3,065 37	
For publishing Smithsonian reports, 8vo......	283 45	
For meteorology, salaries of clerk and computers, and for thermometers and rain-gauges..	3,119 00	
For apparatus for researches..................	249 70	
For explorations, natural history, and archæology..................................	1,414 13	
Lectures..................................	755 00	
		$15,873 22

MUSEUM AND EXCHANGES.

For literary and scientific exchanges, through agencies at Leipsic, London, Paris, Amsterdam, &c..................................	$4,165 62	
For museum, salary of assistant secretary and assistants in museum, and for incidentals in addition to the appropriation from Congress.	5,008 84	
For purchase of books, periodicals, &c........	249,76	
		9,424 22
Expenditures during 1870..........................		44,981 22

Estimated receipts for 1871.

From interest on Smithson fund, in Treasury of the United States..	$39,000 00
Probable premium on gold, 10 per cent. on the above $39,000..	3,900 00
Sale of books, &c..................................	1,000 00
Total..	43,900 00

Estimated appropriations for 1871.

For general expenses..................................	$10,000 00
For publications, researches, &c........................	20,000 00
For exchanges..	5,000 00
For purchase of books and apparatus	2,400 00
For museum, (additional to congressional appropriation) ..	1,500 00
For steam heating-apparatus fund........................	5,000 00
Total..	43,900 00

Besides the above estimated receipts, there is in bank, as before stated in the general account, the sum of $21,477 81.

The committee have examined six hundred and twenty-one receipted vouchers for payments made during the four quarters of the year 1870. In every case the approval of the Secretary of the Institution is given on each voucher, and the certificate of an authorized agent of the Institution is appended, setting forth that the materials and property and services rendered were for the Institution, and to be applied to the purposes stated in the account.

The quarterly accounts-current, bank-book, check-book and ledger were also examined and found to be correct, showing a cash balance in bank on January 1, 1871, of $21,477 81.

All of which is respectfully submitted.

PETER PARKER,
JOHN MACLEAN,
Executive Committee.

JANUARY 26, 1871.

JOURNAL OF PROCEEDINGS

OF

THE BOARD OF REGENTS

OF THE

SMITHSONIAN INSTITUTION.

WASHINGTON, *May* 23, 1870.

A meeting of the Board of Regents was held this evening, at the call of the Secretary. Present: Hon. L. P. Poland, Hon. L. Trumbull, Hon. J. A. Garfield, Hon. S. S. Cox, General Delafield, Hon. Peter Parker, Rev. Dr. J. Maclean, and Professor Henry, the Secretary.

In the absence of the Chancellor, Judge Poland was called to the chair.

The Secretary presented the report of the expenditures on account of the Government collections for the year 1869; and, on motion of General Garfield, it was resolved that the Board of Regents apply to Congress for an appropriation of $10,000 for the care of the Government collections during the year 1870.

Professor Henry stated that the resolution of the board adopted at the meeting of February 3, 1870, authorizing him to visit Europe, had been entirely unexpected to him, as he had received no intimation previous to its being offered that it was in contemplation; that he had concluded to avail himself of the resolution, and that he was making preparations for his departure on the 1st of June; that he intended to make arrangements for the operations of the Institution which were to be carried on during his absence; that he intended to settle all the accounts which would be due at the time of his departure; to deposit checks for the salaries accruing during his absence, to be paid on the indorsement of Professor Baird; and also to deposit to the credit of that officer $2,000, to pay transportation and incidental expenses; that he had been much gratified with the expressions of kind feeling which had been called forth by the announcement of his intended visit to Europe, and the offers which he had received from the Cunard and Bremen lines of steamers of a free passage across the ocean.

The board then adjourned.

WASHINGTON, *January* 18, 1871.

In accordance with a resolution of the Board of Regents of the Smithsonian Institution, fixing the time of the beginning of their annual meet-

ing on the third Wednesday in January of each year, the Board met this day in the Regents' room.

No quorum being present, the Board adjourned to meet on Thursday, January 26.

WASHINGTON, *January* 26, 1871.

A meeting of the Board of Regents was held at 7 p. m. in the Regents' room. Present: Hon. H. Hamlin, Hon. L. P. Poland, Hon. J. A. Garfield, Hon. M. G. Emery, Hon. P. Parker, Rev. Dr. J. Maclean, and the Secretary, Professor Henry.

In the absence of the Chancellor, Mr. Hamlin was called to the chair.

The minutes of the last meeting were read and approved.

The Secretary mentioned his visit to Europe, and stated the fact that it had been highly satisfactory in regard to the foreign correspondents of the Institution and the estimation in which the establishment is held in the Old World.

Whereupon, on motion of General Garfield, he was requested at some future meeting to give a detailed account of his tour, particularly in its relation to the operations of the Institution.

The Secretary gave an account of the operations of the Institution since the last meeting of the Board. He stated that in accordance with the resolution of the Board adopted at the meeting of February 3, 1870, he had effected an insurance of $10,000 on the east wing and range of the building, at 66⅔ per cent.; that Congress has appropriated $10,000 for the care of the Government collections for the year ending June 30, 1871, of which $5,024 has already been drawn; that Congress has also appropriated $10,000 toward the completion of the upper hall, which sum is to be expended under the direction of the Secretary of the Interior, who has directed the Architect of the Capitol (Mr. E. Clark) to oversee the work.

The Secretary read a letter from the agents of the Anchor Line of steamers, offering to carry the Italian exchanges of the Smithsonian Institution by their vessels free of charge.

On motion of General Garfield, the Secretary was directed to present the thanks of the Board to the agents of that line, and also to the agents of the lines that had offered him a free passage to Europe.

Dr. Maclean stated that the majority of the executive committee had decided to alter their report for 1869 to conform to the mode previously adopted.

The Secretary stated that the business of the Institution had of late years so much increased that it was no longer possible to conduct it without further assistance. That this was the case would be evident from the following statement:

The Institution has now upwards of 1,800 foreign correspondents connected with the exchanges. It has 400 regular meteorological observery. It is in communication with almost all the colleges, libraries, literars, and scientific societies in America, besides being continually called upon by individuals in every part of the country for information on scientific subjects. It publishes annually upward of a thousand printed pages, requiring much labor in correcting copy, reading proof, and attending to the details of printing, binding, &c. Its system of international exchanges, exclusive of the correspondence, involves a large amount of time and labor in doing up and directing the separate packages sent away, and in receiving and distributing those from abroad. Several thousand volumes are annually received from foreign and domestic exchanges, which are all recorded at the Institution previous to being deposited in the Library of Congress. The arrangement of the material constantly received from the meteorological observers, supplying them with blanks and instructions, occasions another draught on the labors of the working corps of the Institution.

The continual repairs and care of the building are another item requiring supervision, besides the reconstruction of the parts of the edifice destroyed by the fire. But above all, the entering and care of the thousands of specimens which are constantly received, their assortment, and distribution of duplicates, is sufficient to occupy the entire time of a separate corps of assistants. It may be said with truth that in no institution has more work been done with a smaller number of persons than at the Smithsonian.

The difficulty in carrying on the operations of the Institution had been increased since the last meeting of the Board by the resignation of Mr. Rhees, who had held the position of chief clerk for seventeen years. He had, however, lately learned that Mr. Rhees might be induced to return to his former position, to which the Secretary desired to recall him.

On motion of General Garfield, it was

Resolved, That the Secretary be allowed to appoint a permanent assistant as chief clerk, at a salary not to exceed $175 per month.

General Garfield presented a letter from General Delafield, tendering his resignation as a Regent of the Smithsonian Institution.

Mr. Poland offered the following resolution, which was adopted unanimously:

Resolved by the Board of Regents, That they entertain the highest appreciation of the services of General Richard Delafield as a member of the Board, and especially as a member of the executive committee, and greatly regret the loss caused by his resignation, and desire to express to him, upon his retirement, their strong personal regard.

Dr. Parker presented the report of the executive committee for 1870, which was read and accepted.

The board then adjourned to meet at the call of the Secretary.

WASHINGTON, *March* 9, 1871.

A meeting of the Board of Regents was held this evening at 7 o'clock. Present: Hon. H. Hamlin, Hon. L. P. Poland, Hon. S. S. Cox, Hon. P. Parker, General W. T. Sherman, and the Secretary, Professor Henry.

Judge Poland was called to the chair.

The minutes of the last meeting were read and approved.

The Secretary stated that by joint resolution of Congress, Genera William T. Sherman had been elected a Regent for the term of six years, *vice* Richard Delafield, resigned.

On motion of Mr. Hamlin, the vacancy existing in the executive committee was filled by the election of General Sherman.

The Secretary called attention to the fact that the mayor of the city of Washington was *ex officio* a Regent, but that under the new territorial government the office of mayor ceased, and suggested the propriety of action by Congress to substitute the governor of the Territory as the *ex officio* member of the board.

Messrs. Hamlin and Poland expressed their intention to bring the subject before Congress immediately, and anticipated no objection to the passage of an act providing for the change contemplated.

The Secretary gave an account of the improvements now being made in the building under the appropriation by Congress. The new hall would soon be finished, and it was proposed to devote it mainly to ethnology. Mr. B. Waterhouse Hawkins had been employed to prepare illustrations of extinct animals, &c., to decorate the walls.

The Secretary called attention to the books belonging to James Smithson, the founder of the Institution, and requested some action in relation to the best manner of their preservation. It was thought proper to preserve them in a metallic case with plate-glass front, open to the view of the public, but not to be taken out by any one.

The Secretary presented his annual report for 1870, which was read and accepted.

The board then adjourned *sine die.*

GENERAL APPENDIX

TO THE

SMITHSONIAN REPORT FOR 1870.

The object of this Appendix is to illustrate the operations of the Institution by reports of lectures and extracts from correspondence, as well as to furnish information of a character suited especially to the meteorological observers and other persons interested in the promotion of knowledge.

EULOGY ON PROF. ALEXANDER DALLAS BACHE,
LATE SUPERINTENDENT OF THE UNITED STATES COAST SURVEY.

By Prof. Joseph Henry.

Prepared at the request of the Board of Regents of the Smithsonian Institution, and also of the National Academy of Sciences.

Alexander Dallas Bache, whose life and character form the subject of the following eulogy, was the son of Richard Bache, one of eight children of Sarah, the only daughter of Dr. Benjamin Franklin. His mother was Sophia Burret Dallas, daughter of Alexander J. Dallas, and sister of George M. Dallas, whose names are well known in the history of this country, the former as Secretary of the Treasury, and the latter as Vice-President of the United States, and subsequently as minister to the Court of St. James.

The subject of our sketch was born in Philadelphia, on the 19th of July, 1806. At an early age he became a pupil of a classical school, and was distinguished by an unusual aptitude in the acquisition of learning. Shortly before arriving at the age of fifteen he was appointed a cadet at the National Military Academy at West Point. Here, though the youngest pupil, he soon attained a high grade of scholarship, which he maintained during the whole of his course, and was finally graduated in 1825, at the head of his class. His merit was in this case the more conspicuous, inasmuch as the class is shown to have been one of unusual ability, by having numbered no less than four successful candidates for the honor of adoption into the Corps of Engineers. It has been mentioned as a solitary instance in the history of the Academy, noted for its rigid discipline, that young Bache passed through the entire course of four years without having received a mark of actual demerit, and, what is perhaps not less uncommon, without having called forth the least manifestation of envy on the part of his fellow-pupils. On the contrary, his superiority in scholarship was freely acknowledged by every member of his class, while his unassuming manner, friendly demeanor, and fidelity to duty secured him the affection as well as the respect of not only his fellow-pupils, but also of the officers of the institution. It is also remembered that his classmates, with instinctive deference to his scrupulous sense of propriety, forbore to solicit his participation in any amusement which in the slightest degree conflicted with the rules of the Academy. So far from this, they commended his course, and took pride to themselves,

as members of his class, in his reputation for high standing and exemplary conduct. His room-mate, older by several years than he was, and by no means noted for regularity or studious habits, constituted himself, as it were, his guardian, and sedulously excluded all visitors or other interruptions to study during the prescribed hours. For this self-imposed service, gravely rendered as essential to the honor of the class, he was accustomed jocularly to claim immunity for his own delinquencies or shortcomings. But whatever protection others might require on account of youth and inexperience, young Bache needed no guardian to keep him in the line of duty. Impressed beyond his years with a sense of the responsibility which would devolve upon him as the eldest of his mother's family, entertaining a grave appreciation of the obligations involved in his education at the National Academy, he resolved from the first to exert his energies to the utmost in qualifying himself for the duties which he might be called upon to discharge, whether in professional or private life. Nor was he uninfluenced in this determination by a consciousness that as a descendant of Franklin he was, in a certain degree, an object of popular interest, and that on this account something more than an ordinary responsibility rested upon him. On a mind constituted like his an influence of this kind could not but exert a happy effect.

The character which he established for gentleness of manner and evenness of temper was not entirely the result of native amiability, for when a child he is said to have been quick-tempered, and at later periods of his life, when suddenly provoked beyond his habitual power of endurance, he sometimes gave way to manifestations of temper which might have surprised those who only knew him in his usual state of calm deportment. These ebullitions were, however, of rare occurrence, and always of short duration. His marked characteristic was the control which he had acquired over his passions and feelings, and it was this which enabled him to suppress all tendency to self-indulgence, to pursue with unremitting perseverance the course he had marked out, to observe an undeviating regard for truth and justice, and to cherish habitually all that would tend to exemplify the kindlier affections of the heart.

Although young Bache was perhaps predisposed, from hereditary influence, to form correct habits and adopt high moral principles, yet these dispositions might have remained dormant had it not been for the early training and the watchful care of his noble mother. From his earliest days she checked with gentle reproof every indication of childish revolt against wholesome restraint, and steadily carried out her system of discipline so gently and yet so effectually that it met with scarcely any opposition, and left the conviction that she was always in the right. Her maternal solicitude did not end with his being placed under military rule, but was continued through his whole course by means of a ready pen. In the language of one who was permitted to

read her letters to her son while at West Point, "nothing could be more admirable than the way in which, amid pleasant gossip and family news, she would inspire her son with high sentiments and encourage him to persevering industry."

As an illustration of his persistency of purpose, it is related that, when a recitation of more than common length or difficulty was to be prepared for the morrow, it was no unusual practice of his to place himself on a seat of unstable equilibrium, which by giving way when volition was about to lose its power recalled his flagging attention to the allotted task.

After graduating he was selected, on account of his scholarship, to remain at the Academy as an assistant professor. In this position, which gave him an opportunity to review his studies and extend his reading, he continued one year; when, at his own request, he was assigned to engineering duty under the late General, then Colonel, Totten, at Newport, Rhode Island. Here he remained two years, engaged in constructing fortifications, devoting his extra hours to the study of physics and chemistry, and, as a recreation, collecting and labeling the shells of that region. But the most important event of this period of his life, and that which, doubtless, contributed in a large degree to his future success, was his becoming acquainted with and subsequent betrothal to Miss Nancy Clarke Fowler, the daughter of an old and highly-respected citizen of Newport. With the stinted pay of a lieutenant of engineers, out of which his mother and her younger offspring were to be provided for, marriage was not to be thought of, excepting as an event in the remote distance. Fortunately as unexpectedly, however, a change now took place in his circumstances which enabled him to gratify the earnest wish of his heart and to secure to himself a companion and helpmate who lavished upon him all her affections, and through his life ardently devoted all her thoughts and energies to sustain, assist, and encourage him. The change alluded to, and which opened to him an uninterrupted career of usefulness during the whole of his active life, was the result of an invitation to the chair of natural philosophy and chemistry in the University of Pennsylvania, at Philadelphia. He accepted the position with that unaffected diffidence which is the usual concomitant of true but untried merit, though, as might have been anticipated, his eventual success was commensurate with the industry and ability which had marked his previous progress. Having already had some experience as a teacher, he the more readily gained the entire confidence of the authorities of the university and the affection of his pupils. He did not, however, rest satisfied with the occupation of teacher, or with merely imparting knowledge obtained by the labors of others, but sought to enlarge the bounds of science by discoveries of his own. As auxiliary to this, he became a member of the Franklin Institute, a society then newly established for the promotion of the mechanical arts. This society, which still maintains a vig-

orous existence, was well calculated to exhibit his talents and develop his character. It brought him into intimate association with the principal manufacturers, engineers, and artisans of the city, and into relations of friendship with a large number of young men destined, in more advanced life, to exert an extended influence on public affairs. He was appointed chairman of one of the most important of its committees, and was chosen as the expounder of the principles of the institute at its public exhibitions. Facilities were thus afforded him for the prosecution of science, which he could not have well commanded in any other position. Workshops were thrown open to him, and skillful hands yielded him ready assistance in realizing the conceptions of his suggestive mind. His descent from the illustrious statesman and philosopher whose name the institute bears, and who is almost regarded as the tutelar saint of Philadelphia, no doubt contributed to a prepossession in his favor, but the influence which he acquired and maintained was due to his own learning, industry, ability, and courtesy. To these he owed the favor and distinction of having conferred upon him the principal directorship of the scientific investigations of the institute, and the opportunity which it afforded him of so greatly contributing to the usefulness of the society and to the advancement of his own reputation.

For a full account of the labors in which he was engaged in his connection with the Franklin Institute we must here be content with referring to the volumes of its journal from 1828 to 1835 inclusive. We may pause a moment, however, to notice the investigations relating to the bursting of steam-boilers, of which he was the principal director. The public mind had, at that epoch, been so frequently and painfully called to this subject that the institute was induced to organize a series of systematic researches in regard to it, the importance of which was soon recognized by the General Government in the form of an appropriation for defraying the attendant expenses. In the prosecution of these inquiries a large amount of information relative to explosions, and suggestions as to their causes, was first collected by correspondence, and on this was based a series of well-devised experiments, which were executed with signal address, and the results interpreted with logical discrimination. The conclusions arrived at were embodied in a series of propositions, which, after a lapse of more than thirty years, have not been superseded by any others of more practical value. The most frequent cause of explosion was found to be the gradual heating of the boiler beyond its power of resistance; and next to this, the sudden generation of steam by allowing the water to become too low, and its subsequent contact with the overheated metal of the sides and other portions of the boiler. The generation of gas from the decomposition of water as a cause of explosion was disproved, as was also the dispersion of water in the form of spray through superheated steam. These experiments were not unattended with danger, and required, in their execution, no small amount of personal courage. Accidents were immi-

nent at almost every stage of the investigation; and in some instances explosions were produced which alarmed the neighborhood. So true is it that in the pursuit of science dangers are oftentimes voluntarily encountered, exacting no less courage or firmness of nerve than that which animates the warrior in the more conspicuous but scarcely more important conflicts of the battle-field.

The attention of Mr. Bache at this period was not exclusively devoted to his labors in connection with the Franklin Institute. He was also a member of the American Philosophical Society, and, as such, in association with Hare, Espy, and others interested in the pursuit of various branches of physics and chemistry. He erected an observatory in the yard of his dwelling, in which, with the aid of his wife and of his former pupil, John F. Fraser, he determined with accuracy, for the first time in this country, the periods of the daily variations of the magnetic needle, and by another series of observations the connection of the fitful variations of the direction of the magnetic force with the appearance of the aurora borealis.

Again, in connection with his friend, Mr. Espy, he made a minute survey of a portion of the track of a tornado, which visited New Brunswick, in New Jersey, on the 19th of June, 1835, and from the change of place and relative position of the trees and other objects, as left by the wind, he succeeded in establishing the fact, in accordance with the hypotheses of Mr. Espy, that the effects of the storm were due to an ascending and progressive column of air, by which all objects within the influence of the disturbance, on either side the track, were drawn inward, and not due, as had been supposed, to a horizontal rotation at the surface, which would tend to throw them outward by centrifugal projection. In coöperation with Professor Courtenay, he also made a series of determinations of the magnetic dip at various places in the United States. Indeed, terrestrial magnetism was with him a favorite subject, to which he continued to make valuable contributions at intervals during his whole life. The phenomena of heat likewise engaged much of his attention, and he was the first to show, contrary to generally-received opinion, that the radiation and consequent absorption of dark heat is not affected by color. His investigations in this line were suddenly brought to a close by an accident, which we may be allowed to mention as furnishing an illustration of his self-control and considerate regard for the feelings of others. After an expenditure of money which he could ill afford, and of time withdrawn from the hours due to repose, he had procured and arranged on a stand a series of delicate instruments intended for a long-meditated experiment on radiant heat. During his temporary absence his mother, in hurriedly passing through the apartment, accidentally caught in her dress the support of the apparatus and brought the whole to the floor, a mass of mingled fragments. The author of this disaster was so painfully affected by the destruction, of which she had been the unintentional cause, as to be

obliged to leave to his wife the task of breaking the unwelcome tidings to her son. On receiving the information, he stood for a moment, perfectly silent, then hurried out into the open air to conceal his emotion and tranquilize his feelings. After a short interval he returned, calm, affectionate, and apparently cheerful, and neither by word nor look gave any indication of the pain and disappointment he had so severely experienced.

It should not be forgotten that the labors to which we have alluded were performed in hours not devoted to his regular duties as a professor in the university. To these he was obliged to give three hours a day, besides other time to the preparation of illustrations for his lectures, while several evenings of the week were claimed by committees of the Franklin Institute and the Philosophical Society. He was enabled to execute these multifarious labors by a division of his time into separate periods, to each of which was allotted its special occupation. By a rigid adherence to this system he was always prompt in his engagements, was never hurried, and found time, moreover, to attend to the claims of friendship and society. He was a zealous and successful teacher, to whom the imparting of knowledge was a source of unalloyed and inexhaustible pleasure. His pupils could not fail to be favorably impressed by his enthusiasm and influenced by his kindness. He always manifested an interest not only in their proficiency in study, but also in their general welfare. They regarded him with affection as well as respect, and while in other class-rooms of the university disorder and insubordination occasionally annoyed the teachers, nothing was to be witnessed in his, but earnest attention and gentlemanly deportment.

His success as an instructor affords a striking confutation of the fallacy which has not unfrequently been advocated in certain quarters, that men devoted to original research and imbued with habits of mind which it generates are not well qualified for the office of instructors. So far is the proposition from having any foundation in fact, that it is precisely among the most celebrated explorers of science of the present century that the most successful and noted teachers have been found. In proof of this the illustrious names of Priestley, De Candolle, Dalton, Davy, Oersted, Faraday, and a host of others, immediately occur. At the same time it cannot be denied that it is questionable economy to devote to the drudgery of drilling youth in the elements of knowledge, a mind well qualified by nature and training to enlarge the boundaries of thought and increase the stores of knowledge. But it is equally clear that the practice of teaching is, to a certain extent, not incompatible with the leisure and concentration of mind requisite for original research; that the latter must, in fact, act beneficially alike on the instructor and instructed; the former gaining in clearness of conception in the appreciation of the new truths he is unfolding by imparting a knowledge of their character to others, while the latter catch, by sym-

pathy, a portion of the enthusiasm of the master, and are stimulated to exertions of which they would otherwise be incapable.

In 1836, when Professor Bache had just attained the thirtieth year of his age, his attention and energies received a new direction, constituting, as it were, a new epoch in his life. This change was caused by a movement on the part of the trustees of the Girard College for Orphans, an institution munificently endowed by a benevolent citizen of Philadelphia. Preparatory to organizing this institution it was thought desirable to select a suitable person as president, and to send him abroad to study the systems of education and methods of instruction and discipline adopted in Europe. The eyes of the entire community were with one accord directed to our professor as the proper man for this office. He had, however, become enamored with the pursuit of science, and it was with difficulty that he could bring himself to regard with favor a proposition which might tend to separate him from this favorite object. The consideration of a more extended field of usefulness at length prevailed, and he accepted, though not without some lingering regret, the proffered position. No American ever visited Europe under more favorable circumstances for becoming intimately acquainted with its scientific and literary institutions. His published researches had given him a European reputation, and afforded him that ready access to the intelligent and influential classes of society which is denied the traveler whose only recommendation is the possession of wealth. It cannot be doubted that he was also favored in this respect by the admiration which in Europe still attaches to the name of his renowned ancestor.* He was everywhere received with marked attention, and from his moral and intellectual qualities did not fail to sustain the prepossessions in his favor and to secure the friendship and esteem of the most distinguished savants of the Old World.

He remained in Europe two years, and on his return embodied the results of his researches on education in his report to the trustees of Girard College. This report forms a large octavo volume, and is an almost exhaustive exposition of the scholastic systems and methods of instruction in use at the time in England, France, Prussia, Austria, Switzerland, and Italy. It has done more, perhaps, to improve the theory and art of education in this country than any other work ever published; and it has effected this not alone by the statement of facts derived from observation, but also by the inferences and suggestions

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*The force of this sentiment was quaintly but strongly marked by a slight incident which occurred when he was in Germany. An elderly savant, on being introduced, clasped him in his arms, saluted him with a kiss on either cheek, and greeted him with the exclamation, "Mein Gott, now let me die, since I have lived to see with mine own eyes an emanation of the great Franklin!" This compliment was perhaps more flattering than agreeable, since the old professor in question was wont, after the fashion of his day, to stimulate his lagging faculties by frequent and profuse extractions from the snuff-box.

with which it abounds. The accounts which are given of the different schools of Europe are founded on personal inspection; the results being noted down at the time with the writer's habitual regard to accuracy.

After completing his report he was prepared to commence the organization of the Girard College, but the trustees, partly on account of the unfinished condition of the building, and partly from a delay in the adjustment of the funds of the endowment, were not disposed to put the institution into immediate operation. In the mean time Professor Bache, desirous of rendering the information he had acquired of immediate practical use, offered his services gratuitously to the municipal authorities of Philadelphia, to organize, on an improved basis, a system of public education for that city. This offer was gladly accepted, and he commenced the work with his usual energy and with the cordial support of the directors and teachers of the common schools. At the end of the year, finding that the trustees of the college were still unprepared to open the institution, he relinquished the salary, but retained the office of president, and devoted his time mainly to the organization of the schools. He was now, however, induced to accept from the city, as the sole and necessary means of his support, a salary much less than the one he had relinquished. The result of his labors in regard to the schools was the establishment of the best system of combined free education which had, at that time, been adopted in this country. It has since generally been regarded as a model, and has been introduced as such in different cities of the Union.

In 1842, having completed the organization of the schools, and Girard College still remaining in a stationary condition, he resigned all connection with it, and, yielding to the solicitations of the trustees of the university, returned to his former chair of natural philosophy and chemistry, in order that he might resume the cultivation of science. Not that it is to be inferred that in his devotion to the advancement of education he had relinquished or deferred the scientific pursuits to which the habit of his mind and the bent of his genius continually impelled him, for during his travels in Europe he had been careful to provide himself with a set of portable instruments of physical research, and, as a relief from the labors imposed by the special object of his mission, he instituted a connected series of observations at prominent points on the Continent and in Great Britain, relative to the dip and intensity of terrestrial magnetism. These observations were made with the view of ascertaining the relative direction and strength of the magnetic force in Europe and America, by the comparison of parallel series of observations in the two countries with the same instruments. They also served, in most instances, to settle with greater precision than had previously been attained the relative magnetic condition of the points at which they were made.

Though the organization of the schools of such a city as Philadelphia might seem sufficient to absorb all his energy and self devotion, yet

even in the midst of this labor we find our late colleague actively coöperating in the great enterprise of the British Association to determine by contemporaneous observations, at widely separated points, the fluctuations of the magnetic and meteorological elements of the globe. This coöperation, in which no doubt a feeling of national pride mingled itself with his ardor for the advancement of science, consisted primarily in the establishment of an observatory, to which the trustees of Girard College contributed a full series of instruments, combining all the latest improvements, and which was supported by the American Philosophical Society, and a number of liberal and intelligent individuals. The observations which were here continued at short intervals, both by day and night, for five years, form a rich mine of statistics, from which, until within the last few years of his life, the professor drew a highly interesting series of results, without exhausting the material. In addition to these observations, he made during his summer vacations a magnetic survey of Pennylvania.

He was not destined to remain long in his old position in the university. Before he had become fairly settled in it and had renewed his familiarity with its duties, he was called in November, 1843, on the occasion of the death of Mr. Hassler, Superintendent of the United States Coast Survey, to fill the important sphere of public duty thus rendered vacant. His appointment to this position was first suggested by the members of the American Philosophical Society, and the nomination fully concurred in by the principal scientific and literary institutions of the country. In this movement he himself took no part, and indeed regarded the position as one not to be coveted; for while it opened a wide field for the exercise of talent and the acquisition of an enviable reputation, it involved responsibilities and presented difficulties of the gravest character. Professor Bache was not one of those who, abounding in self-confidence, imagine themselves equal to every exigency, or who seek the distinctions and emoluments of office without any regard to the services to be rendered or the duties to be discharged. On the contrary, though early and continued success must have tended to increase his self-esteem, each new position to which he was called was entered upon with feelings of solicitude rather than of exultation. He rightly judged that the proper moment for self-congratulation is not at the beginning of an arduous and precarious enterprise, but at the time of its full and successful accomplishment. Nor can it be necessary to add that this characteristic contributed largely to his success. In civil service as in the camp, the leader to whom all look with confidence is not he who, with blind and arrogant self-reliance, disdains caution as unworthy of courage, but he who, sensitively alive to the dangers to be encountered, exerts every faculty in calling to his aid every resource which may tend to secure victory or facilitate retreat.

With whatever misgivings Professor Bache may have undertaken the task to which he was assigned, it may be truly said that no living

man was so well qualified as himself to secure the results which the nation and its commercial interests demanded. His education and training at West Point, his skill in original investigations, his thorough familiarity with the principles of applied science, his knowledge of the world, and his gentlemanly deportment, were all in a greater or less degree essential elements in the successful prosecution of the survey. It would appear as if the training and acquisition of every period of his life, and the development of every trait of his character, had been especially ordained to fit him in every respect to overcome the difficulties of this position. Besides the qualifications we have enumerated, he possessed rare executive ability, which enabled him to govern and guide the diverse elements of the vast undertaking with consummate tact and skill. Quick to perceive and acknowledge merit in others, he rapidly gathered around him a corps of men eminently well qualified for the execution of the tasks to which he severally assigned them.

The Coast Survey had been recommended to Congress by President Jefferson as early as 1807, but it was not until ten years afterward that the work was actually commenced, under the superintendence of Professor Hassler, an eminent Swiss engineer, whose plans had been previously sanctioned by the American Philosophical Society. Though the fundamental features of the survey had been established on the most approved scientific principles yet so frequent were the changes in the policy of the Government, and so limited were the appropriations, that, even up to the time of Professor Bache's appointment, in 1843, little more than a beginning had been made. The survey, so far as accomplished, extended only from New York Harbor to Point Judith, on the east coast, and southward to Cape Henlopen. The new Superintendent saw the necessity of greatly enlarging the plan, so as to embrace a much broader field of simultaneous labor than it had previously included. He divided the whole coast line into sections, and organized, under separate parties, the essential operations of the survey simultaneously in each. He commenced the exploration of the Gulf Stream, and at the same time projected a series of observations on the tides, on the magnetism of the earth, and the direction of the winds at different seasons of the year. He also instituted a succession of researches in regard to the bottom of the ocean within soundings, and the forms of animal life which are found there, thus offering new and unexpected indications to the navigator. He pressed into service, for the determination of the longitude, the electric telegraph; for the ready reproduction of charts, photography; and for multiplying copper-plate engravings, the new art of electrotyping. In planning and directing the execution of these varied improvements, which exacted so much comprehensiveness in design and minuteness in detail, Professor Bache was entirely successful. He was equally fortunate, principally through the moral influence of his character, in impressing upon the Government, and especially upon Congress, a more just estimate of what such a survey required for its maintenance and

creditable prosecution. Not only was a largely-increased appropriation needed to carry out this more comprehensive plan, but also to meet the expenses consequent upon the extension of the shore-line itself. Our sea-coast, when the survey commenced, already exceeded in length that of any other civilized nation, but, in 1845, it was still more extended by the annexation of Texas, and again, in 1848, by our acquisitions on the Pacific. Professor Bache was in the habit of answering the question often propounded to him by members of Congress, "When will this survey be completed?" by asking, "When will you cease annexing new territory?" a reply not less significant at the present day than when it was first given, and which may continue long to be applicable under the expansive tendencies of our national policy.

When Professor Bache took charge of the survey, it was still almost in its incipient stage, subjected to misapprehension, assailed by unjust prejudice, and liable, during any session of Congress, to be suspended or abolished. When he died, it had conquered prejudice, silenced opposition, and become established on a firm foundation as one of the permanent bureaus of the executive Government. The importance of the work, which was always highly appreciated by the mariner, became strikingly obvious to the general public through the service which it rendered during the late war, in furnishing accurate charts and sailing directions for the guidance of our squadrons along the southern coast. Nor was this alone; an active participation was also borne by the officers of the survey in the attack of the United States Navy on Sumter, Port Royal, Fort Fisher, Mobile, New Orleans, and other strongholds, while constant aid was rendered by them in the navigation of the inlets and channels, and in the avoidance of hidden rocks or shoals with which none could be more minutely acquainted. Though the value of the survey was signally conspicuous on these occasions, it needs but little reflection to be convinced of its essential connection with the general prosperity of the country. Whatever diminishes the danger of departure from or an approach to our shores facilitates commerce, and thus renders more valuable the products of our industry, even in portions of our land most remote from the sea-board. But the survey should not be viewed alone in its economical relations, since, as an enlightened and liberal people, we owe it to the great community of nations and the cause of humanity to supply the world with accurate charts of our precarious coast, as well as to furnish it with all the other aids to safer navigation which the science and experience of the age may devise.

Professor Bache, with his enlightened appreciation of the value of abstract science, kept constantly in view the various problems relative to the physics of the globe, which are directly or even incidentally connected with the survey of the coast, and ever cherished the hope of being permitted to complete his labors by their solution. Among these was a new determination of the magnitude and form of the earth, and the variations in the intensity of terrestrial gravity at various points on

the continent of North America; the discussion of the general theory of the tides; the magnetic condition of the continent; and the improvement of the general map of the United States, by determining its relation to the coast line, and the precise geographical positions of the most important points in the interior. Though his hopes in regard to these problems were not destined to be realized by himself, fortunately for the cause of science they have been left in charge of a successor in the person of his ardent friend and collaborator. Professor Peirce, to whose genius and industry we may confidently look for that full exposition of the work which, while it entitles him to the highest approbation of the scientific world, will render ample justice to the labors and sagacity of his lamented predecessor.

Besides having charge of the Coast Survey, Professor Bache was Superintendent of Weights and Measures, and in the exercise of this function directed a series of investigations relative to the collection of excise duties on distilled spirits, and likewise superintended the construction of a large number of sets of standard weights and measures for distribution among the several States of the Union. He was also appointed one of a commission to examine into the condition of the light-house system of this country, and to report upon any improvements calculated to render it more efficient. In the investigations pertaining to this subject, involving, as they do, a knowledge of a wide range of applied science, he took a lively interest, and rendered important service in the organization of the admirable system which was adopted and still remains in operation. This commission of investigation was afterward merged in the present Light-House Board, of which he continued a member until the time of his death.

In 1846 he had been named in the act of incorporation as one of the Regents of the Smithsonian Institution, and by successive reëlection was continued by Congress in this office until his death, a period of nearly twenty years. To say that he assisted in shaping the policy of the establishment would not be enough. It was almost exclusively through his predominating influence that the policy which has given the institution its present celebrity was, after much opposition, finally adopted. The object of the donation, it will be remembered, had been expressed in terms so concise that its import could scarcely be at once appreciated by the general public, though to the cultivators of science, to which class Smithson himself belonged, the language employed failed not to convey clear and precise ideas. Out of this state of things it is not surprising that difference of opinion should arise respecting the proper means to be adopted to realize the intentions of the founder of the institution. Professor Bache with persistent firmness, tempered by his usual moderation, advocated the appropriation of the proceeds of the funds principally to the plan set forth in the first report of the Secretary, namely, of encouraging and supporting original research in the different branches of science. Unfortunately this policy could only be

partially adopted, on account of the restrictions of the enactment of Congress, by which provision was to be made for certain specified objects. He strenuously opposed the contemplated expenditure of a most disproportionate sum in the erection and maintenance of a costly edifice; but failing to prevent this, he introduced the resolution adopted by the board as a compromise, whereby the mischief which he could not wholly avert might at least be lessened. This resolution provided that the time of the erection of the building should be extended over several years, while the fund appropriated for the purpose, being in the mean time invested in a safe and productive manner, would serve in some degree to counterbalance the effect of the great and unnecessary outlay which had been resolved on. It would be difficult for the secretary, however unwilling to intrude anything personal on this occasion, to forbear mentioning that it was entirely due to the persuasive influence of the professor that he was induced, almost against his own better judgment, to leave the quiet pursuit of science and the congenial employment of college instruction to assume the laborious and responsible duties of the office to which, through the partiality of friendship, he had been called. Nor would it be possible for him to abstain from acknowledging with heart-felt emotion that he was from first to last supported and sustained in his difficult position by the fraternal sympathy, the prudent counsel, and the unwavering friendship of the lamented deceased.

His demeanor in the board was quiet and unobtrusive, and his opinions sought no support in elaborated or premeditated argument; but when a topic likely to lead to difficulty in discussion was introduced, he seldom failed, with that admirable tact for which he was always noted, to dispose of it by some suggestion so judicious and appropriate as to secure ready acquiescence and harmonious action. The loss of such a man in the councils of the Institution, when we consider the characteristics which it has been our aim to portray, must, indeed, be regarded as little less than irreparable.

As a vice-president of the United States Sanitary Commission his influence was felt in selecting proper agents, and suggesting efficient means for collecting and distributing the liberal contributions offered for ameliorating the condition of our soldiers during the war. But the services which he rendered the Government during the recent struggle were not confined to this agency, or to the immediate operations of the Coast Survey. He was called into consultations to discuss plans of attack on the part of the Navy, and for its coöperation with the Army. He acted also as a member of a commission to which various projects, professing to improve the art of war, were referred, and in this capacity it is not too much to say that his judicious counsel contributed to save the Government millions of dollars by preventing the adoption of plausible though impracticable propositions from which nothing but failure and loss could have resulted.

One of the last acts of his life was an exemplification of the devoted

affection which he had always borne to his native city, whither it was his cherished intention to return when he should be at last released from official duty. At the request of the governor of Pennsylvania, although overwhelmed with other public labors, he planned lines of defenses for Philadelphia, and to a certain extent personally superintended their construction. Unaccustomed for many years to direct exposure to the sun, this work proved too much for his physical strength and brought on the first indications of that malady which terminated his life. Though apparently of a vigorous constitution, and capable, under the excitement of official life, of bearing an unusual amount of bodily fatigue, yet he was subject at intervals to "sick headaches," a disease which seems to have been hereditary, and which perhaps conspired with other causes in terminating his useful and distinguished career. Previous to the war he had spent the warmer part of each summer in a tent, at some point of the primary triangulation of the survey, whence he directed the various parties in the field by correspondence; and as the point was usually at the top of a mountain, or at some elevated position, from which other stations of the survey could be seen, he did not want for invigorating air. With this, and the exercise of measuring angles he laid in a store of health sufficient to enable him to carry on without interruption the arduous duties of the remaining portion of the year. But after the commencement of the war his presence was continually required in Washington to give advice and information as to military and naval operations, and to attend the meetings of the scientific commission to which we have previously referred. He was, therefore, no longer able to avail himself of the recuperating influence of mountain air, and in view of this his valuable life may be said to have been one of the sacrifices offered for the preservation of the Union. The first indications of the insidious disease which gradually sapped the citadel of life were numbness in the fingers of his right hand, and, on one occasion, for a short time only, loss of memory. Though these symptoms gave him some uneasiness, they did not diminish his exertions in the line of his duty. Other symptoms, however, exhibited themselves, which, though awaking anxiety, did not much alarm his friends, until he was suddenly deprived, in a considerable degree, of the power of locomotion and of the expression of ideas; the result, it was supposed, of a softening of the brain. But though the power of expression was paralyzed, his memory appeared to retain all the impressions of the past, and he evidently took much pleasure in having recalled to him scenes and events of years gone by. For several months he was very anxious as to the business of the Coast Survey, and it was with difficulty he could be restrained from resuming in full the duties of his office; but as the malady increased his perception of external objects diminished. He took less and less interest in passing events, and finally seemed to withdraw his attention from the exterior world, with which he almost ceased thenceforth to hold any active communication. It was hoped that a voyage to Europe, through the excitements of shipboard

and the revival of old associations, would be of service to him; but, notwithstanding an occasional manifestation of his wonted spirit of social and intellectual enjoyment at the encounter of a friend of former times or distinguished associate in the walks of science, he returned from a sojourn abroad of eighteen months without having experienced any permanent abatement in the progress of his malady. He lingered for a short time longer, and finally resigned his breath at Newport, Rhode Island, on the 17th of February, 1867, in the sixty-first year of his age.

It would be impossible to name an American distinguished on purely scientific grounds to whom the enlightened sentiment of his own countrymen and of foreign nations has awarded more emphatic marks of admiration and esteem. The degree of Doctor of Laws was conferred on him by the principal universities of this country, and few of our leading societies were willing to forego the honor of numbering him among their associates. He was elected in succession president of the American Philosophical Society, of the American Association for the Advancement of Science, and, of the National Academy of Sciences established by Congress. Nor were foreigners less forward in acknowledging his merit. He was a member of the Royal Society of London, of the Imperial Academy of Sciences at St. Petersburg, of the Institute of France, the Royal Society of Edinburgh, the Royal and Imperial Geographical Society of Vienna, the Royal Academy of Turin, the Mathematical Society of Hamburg, the Academy of Sciences in the Institute of Bologna, the Royal Astronomical Society of London, and of the Royal Irish Academy of Dublin. In addition to these testimonies of appreciation, several medals were awarded to him by foreign governments for his distinguished services in the Coast Survey and in the cause of science generally.

The life we have here sketched is eminently suggestive, both from a philosophical and a practical point of view. It presents an unbroken series of successful efforts, with no interruptions in its sustained and constantly ascending course; all parts follow each other in harmonious continuity; and not only is each stage of its progress in advance of the one which preceded it, but it furnishes the means of education for that which succeeded. It is not merely curiosity, laudable as that might be, but a sense of the importance of the inquiry, which prompts us to ask, What were the mental and moral characteristics of the mind which produced such results? And we say intentionally, the *mind which produced these results*, for although it be true that accident has in many cases a determining influence on the fortunes of an individual, it will be clear from what precedes, or we shall have greatly failed in the task which we proposed to ourselves, that the element of casualty had but little to do with the success which crowned the life to which the question at present relates.

From long acquaintance with him and critical study of the events of

his life, and the distinctive manifestations of his moral and intellectual nature, we venture, though not without hesitation, to present the following analysis of the character of one who has performed so conspicuous a part, and in whose memory so many are deeply interested.

Alexander Dallas Bache possessed, or we may perhaps say originally inherited, a mind of strong general powers, with no faculty in excess or in deficiency, but, as a whole, capable of unusual expansion or development in any direction which early training or the education of life might determine. He also possessed strong passions, which, instead of exerting an unfavorable effect on his character by their indulgence, became, under the restraining influence to which they were in due season subjected, a reserved energy, as it were, ready to manifest itself spontaneously and at any time in the vindication of truth and justice. He was likewise endowed with a power of *will* which, controlling all his faculties and propensities, rendered them subservient to those fixed purposes which had once received the sanction of his deliberate judgment. Eminent also among his characteristics, and perhaps most conspicuous of all, was the social element of refined humanity, a regard for his fellow-man, which craved as an essential want of his nature fraternal sympathy, not only with those within the wide circle of his daily associations, but with those from whom he could expect no reciprocation of the sentiment, the entire brotherhood of mankind. These characteristics, with a nice perception of right and a conscience always ready to enforce its mandates, are, we think, sufficient to explain the remarkable career we have described.

They were perhaps indicated by himself, though with an admission not to be accepted without some reserve, in a conversation with the writer of this sketch in reference to his entrance at West Point. "I knew," he said, "that I had nothing like genius, but I thought I was capable by hard study of accomplishing something, and I resolved to do my best, and if possible to gain the approbation of the teachers, and, above all, to make myself loved and respected by my classmates."

To illustrate the progressive development of the individual traits of his character, we may be allowed to dwell for a moment on a few analytical details. The early period of his life, including that which preceded his first call to Philadelphia, was almost wholly devoted to the improvement of the mechanical, or the "doing" faculties of his mind, and but little attention was given to invention, or the exercise of original thought. His final examination at the Academy, perfect as it was in its kind, only exhibited his capacity for the acquisition of knowledge not the power to originate or apply it. When his efforts were first turned in the latter direction, he evinced, as I well remember, no especial aptitude for it that would indicate future success; but in a short time, and under the stimulus of the associations into which he was thrown in Philadelphia, the faculties of investigation and of generalization were rapidly developed, and had he not been partially turned aside

from such pursuits, I doubt not but that he would have still more highly distinguished himself in the line of experimental research. Again, the change in the circumstances and relations of his life produced by his election to the presidency of Girard College introduced him to a familiarity with an entirely new class of ideas, which served to exercise and expand another faculty of his mind, that, namely, which observes and appreciates moral truths, though without impairing his aptitude for physical research. In like manner, his foreign mission with reference to popular education, by bringing him into intimate and friendly association with minds of the first order in the principal cities of Europe, afforded him an opportunity for enlarging the sphere of his sympathies, as well as of studying men under a great variety of social and mental peculiarities.

Again, his long residence and high social position at the seat of Government, his intimate acquaintance and friendly intercourse with statesmen and politicians, imbued him with a thorough knowledge of the working of the Government, such as few have ever possessed, while his exertions to sustain the Coast Survey and improve its condition served to call into active operation his power to appreciate character, to discern motives, and, therefore, to convince, persuade, and control men. His ability in this latter respect was remarkable; a personal interview with an opponent of the survey scarcely ever failed to convert perhaps an active enemy into an influential friend. His success in this respect often astonished those who frequently harassed Congress with propositions covertly designed to promote their own interest at the expense of public utility; hence the exclamation was not unfrequently heard, "Bache is certainly a wonderful manager." If that which is unusual constitutes, an element of wonder, then the exclamation was not without truth, though not in the sense of those by whom it was uttered, for he never advocated any measure that was not just, expedient, and proper, either as concerned the interests of the country or the welfare of his species.

On the whole, if we would seek the real secret of his influence over his fellow-men, it would be found, no doubt, to have consisted in the singular abnegation of self which pervaded his whole conduct; his great practical wisdom, his honesty of purpose, and his genial though quiet and unobtrusive manner. In the exercise of these characteristics, he was so far from the least appearance of dissimulation, that no one ever approached him without feeling that it was equally impossible to doubt the purity of his intentions as it was to elude the penetration of his quiet but thorough scrutiny. His calmness served as a shield from within and without; and as a guard against himself as well as a protection against others. It enabled him to weigh the motives and observe the character of those who consulted him with the view of securing his influence or gaining his patronage. His genial nature enabled him to descend gracefully from the heights of science and to enter fully and frankly into the feelings of any company with which he might be

thrown. In this he was aided by a playfulness of fancy and a quiet humor which banished any reserve that might have been produced by a knowledge of his superior talents and attainments. He was, though by no means gifted with those attractions of person which influence at first sight, a favorite with all ages, and particularly with the sex whose discrimination of character is said to be least fallible. It seems almost superfluous to say of such a man that his friendship was open and unwavering, that his confidence once bestowed could be shaken by no mere difference of opinion or conflict of personal interests. Severe to himself under the responsibility of duty, and in the punctual observance of his engagements, his indulgence was reserved for the weak and the erring. Though his outer life was free from disappointments or reverses, and though he walked as it were in perpetual sunshine, all was not so within. Besides the anxiety and solicitude incident to the responsible duties of his position, occasions of trial and profound sorrow were not spared him. He was called to mourn the untimely loss of a beloved brother, who fell a victim to his zeal for the professor's service in the survey of the Gulf Stream; of another brother, the youngest and last, also an officer of the Navy, and a general favorite, who was drowned on the coast of California; and lastly of a sister, whom he had adopted and cherished as a child. In these seasons of affliction he found consolation in the steadfast convictions of religious faith. Nurtured in the forms and principles of the Episcopal church, he was a devout worshiper in the sanctuary, though not bigoted in his attachment to the peculiar ordinances of that communion. He fully recognized the union of science and religion, and held with unwavering constancy the belief that revelation, properly interpreted, and science, rightly understood, must ultimately join in perfect accord in reference to the great truths essential to the well-being of man.

As an evidence of his high appreciation of abstract science derived from original investigation, he left his property in trust to the National Academy of Sciences, the income to be devoted to the prosecution of researches in physical and natural science by assisting experimentalists and observers, and the publication of the results of their investigations.

I here close this imperfect sketch, in which I am conscious of having passed in silence many admirable traits of character and conduct, and of having very inadequately portrayed others, with the remark that, though our companion and brother has departed, his works and his influence still remain to us; that, sorrow as we must for his loss, we can still recall with pride and satisfaction the example he has left us of all that, in heart, in spirit, and in life, the true man of science ought to be.

The following is a list of the published scientific papers of Alexander Dallas Bache, copied from the appendix to an address by Dr. Benjamin

A. Gould, before the American Association for the Advancement of Science, August 6, 1868.

1829—Feb. On the specific heat of the atoms of bodies. *Journ. Phila. Acad. Nat. Sci.*, vi, 141.

1830—May. On the inflammation of phosphorus in a partial vacuum. *Amer. Journ. Sci.*, xviii, 372.

1831—Mar. Report of the committee of the Franklin Institute, of Pennsylvania, appointed May, 1829, to ascertain by experiment the value of water as a moving power. *Journ. Frank. Inst.*, vii, 145; viii, ix, x, &c.

1831—April. Safety apparatus for steamboats, being a combination of the fusible metal disk with the common safety-valve. *Journ. Franklin Inst.*, vii, 217; *Amer. Journ. Sci.*, xx, 317.

1831—Oct. Meteorological observations during the solar eclipse of February 12, 1831. *Trans. Amer. Phil. Soc.*, iv, 132.

1832—July. Translation of Berzelius's Essay on Chemical Nomenclature. *Amer. Journ. Sci.*, xxii, 248; *Philadelphia*, 1832.

1832—July. Notice of experiments on electricity developed by magnetism. *Journ. Franklin Inst.*, x, 66; *Amer. Journ. Sci.*, xxii, 409.

1832—Oct. Alarm to be applied to the interior flues of steam-boilers. *Journ. Franklin Inst.*, x, 217.

1832—Nov. On the diurnal variation of the magnetic needle. *Trans. Amer. Phil. Soc.*, v, 1.

1833—Mar. Elementary view of the application of analysis to reflection and refraction. An appendix to Sir David Brewster's treatise on optics. *Philadelphia*, 1833. pp. 95.

1833—July. Translation of Avogadro's memoir on the elastic force of the vapor of mercury. *Amer. Journ. Sci.*, xxiv, 286.

1833—July. Note of the effect upon the magnetic needle of the aurora borealis, visible at Philadelphia on the 17th of May, 1833. *Journ. Franklin Inst.*, xii, 5; *Amer. Journ. Sci.*, xxvii, 113.

1833—Nov. Attempt to fix the date of Dr. Franklin's observation, in relation to the northeast storms of the Atlantic States. *Journ. Franklin Inst.*, xii, 300.

1833—Dec. Report of experiments on the navigation of the Chesapeake and Delaware Canal by steam. *Journ. Franklin Inst.*, xii, 361.

1834—Jan. Observations on the disturbance in the direction of the horizontal needle, during the occurrence of the aurora of July 10, 1833. *Journ. Franklin Inst.*, xiii, 1; *Amer. Journ. Sci.*, xxvii, 118.

1834—Jan. Report of the managers of the Franklin Institute, in relation to weights and measures. Presented in compliance with a resolution of the house of representatives of the State of Pennsylvania. *Journ. Franklin Inst.*, xiv, 6; *Philadelphia*, 1834.

1834—June. Analysis of some of the coals of Pennsylvania, (made jointly with Professor H. D. Rogers.) *Journ. Phila. Acad. Nat. Sci.*, vii, 158.

1834—Oct. On the variation of the magnetic needle. *Amer. Journ. Sci.*, xxvii, 385.

1834—Nov. Observations to determine the magnetic dip at Baltimore, Philadelphia, New York, West Point, Providence, Springfield, and Albany, (made jointly with Professor E. H. Courtenay.) *Trans. Amer. Phil. Soc.*, v, 209.

1834—Nov. Meteoric observations on and about Nov. 13, 1834. *Amer. Journ. Sci.*, xxvii, 335; *Journ. Franklin Inst.*, xvi, 369.

1835—Jan. Note relating to the hardening of lime under water, by the action of carbonate of potassa, &c., and to the hardening of carbonate of lime in the air, by potassa and soda. *Journ. Frank. Inst.*, xv, 6.

1835—Mar. Meteorological observations made during the solar eclipse of November 30, 1834. *Trans. Amer. Phil. Soc.*, v, 237.

1835—May. Experimental illustrations of the radiating and absorbing powers of surfaces for heat, of the effects of transparent screens, of the conducting power of solids, &c. *Journ. Franklin Inst.*, xv, 303; *Amer. Journ. Sci.*, xxviii, 320.

1835—May. Replies to a circular in relation to the occurrence of an unusual meteoric display on the 13th of November, addressed by the Secretary of War to the military posts of the United States, with other facts relating to the same question. *Amer. Journ. Sci.*, xxviii, 305; *Journ. Franklin Inst.*, xvi, 149.

1835—June. Experiments on the efficacy of Perkins's steam-boilers or circulators. *Journ. Franklin Inst.*, xv, 379.

1835—July. On the comparative corrosion of iron, copper, zinc, &c., by a saturated solution of common salt. *Journ. Franklin Inst.*, xvi, 2.

1835—Nov. Inquiry in relation to the alleged influence of color on the radiation of non-luminous heat. *Journ. Franklin Inst.*, xvi, 289; *Amer. Journ. Sci.*, xxx, 16.

1835—Dec. Historical notice of a hypothesis to explain the greater quantity of rain which falls on the surface of the ground than above it. *Journ. Franklin Inst.*, xvii, 106.

1836—Jan. Observations upon the facts recently presented by Professor Olmsted in relation to meteors seen on the 13th of November, 1834. *Journ. Franklin Inst.*, xvii, 33; *Amer. Journ. Sci.*, xxix, 383.

1836—Jan. Historical note on the discovery of the non-conducting power of ice. *Journ. Franklin Inst.*, xvii, 182.

1836—Jan. Report of experiments made by the committee of the Franklin Institute of Pennsylvania, on the explosions of steam-boilers, at the request of the Treasury Department of the United States. *Journ. Franklin Inst.*, xvii, 1, 73, 145, 217, 289.

1836—Feb. Remarks on a method, proposed by Dr. Thomson, for determining the proportions of potassa and soda in a mixture of the two alkalies; with the application of a similar investigation to a different method of analysis. *Journ. Franklin Inst.*, xvii, 305.

1836—April. Notes and diagrams illustrative of the directions of the forces acting at and near the surface of the earth, in different parts of the Brunswick tornado of June 19, 1835. *Trans. Amer. Phil. Soc.*, v. 407.

1836—May. Or the relative horizontal intensities of terrestrial magnetism at several places in the United States, with the investigations of corrections for temperature, and comparisons of the methods of oscillation in full and in rarefied air, (jointly with Professor E. H. Courtenay.) *Trans. Amer. Phil. Soc.*, v, 427.

1836—July. Proposed forms of diagrams for exhibiting to the eye the results of a register of the direction of the wind. *Journ. Franklin Inst.*, xviii, 22.

1837—May. Corresponding magnetic observations, in connection with Professor Lloyd of Dublin, to determine the relative magnetic intensity in Philadelphia, Dublin, and Edinburgh. *Proc. R. Irish Acad.*, i, 71.

1838—Aug. Note on the effect of deflected currents of air on the quantity of rain collected by a rain-gauge. *Rep. Brit. Assoc. Adv. Sci.*, 1838, ii, 25.

1839—May. Report on education in Europe, to the trustees of the Girard College for Orphans. 8vo. pp. 666. *Philadelphia*, 1839.

1839—Nov. Comparison of Professor Loomis's observations on magnetic dip with those obtained by Professor Courtenay and himself. *Proc. Amer. Phil. Soc.*, i, 146.

1839—Nov. Simultaneous magnetic observations, made in correspondence with Professor Lloyd of Dublin. *Proc. R. Irish Acad.*, i, 462; *Amer. Journ. Sci.*, xli, 212.

1840—Mar. Observations of the magnetic intensity at twenty-one stations in Europe. *Trans. Amer. Phil. Soc.*, vii, 75; *Proc. Amer. Phil. Soc.*, i, 185.

1840—Nov. Determination of the magnetic dip at Philadelphia and Baltimore. *Proc. Amer. Phil. Soc.*, i, 294.

1840—Dec. On an instrument for measuring the changes in the vertical component of the force of terrestrial magnetism *Proc. Amer. Phil. Soc.*, i, 311

1841—May. Diagram of the direction and force of the wind, and amount and rate of rain-fall during the severe gust of April 2, 1841. *Proc. Amer. Phil. Soc.*, ii, 56.

1841—July. On observations of the magnetic dip, made at Baltimore by Mr. Nicollet and Major Graham. *Proc. Amer. Phil. Soc.*, ii, 83.

1841—Nov. Account of the formation of cumulus cloud from the action of a fire. *Proc. Amer. Phil. Soc.*, ii, 116.

1842—Mar. Semi-annual report of the principal of the High School, and report to the controllers of the public schools. *Twenty-fourth Annual Report of Controllers of Public Schools of Philadelphia*, pp. 23, 50.

1842—April. On the application of the self-registering rain-gauge to registering the fall of snow. *Proc. Amer. Phil. Soc.*, ii, 164.

1842—July. Report of the principal of the Central High School for the year ending July, 1842. 8vo. pp. 120. *Philadelphia.*

1842—Oct. Address delivered at the close of the twelfth exhibition of American manufactures, held by the Franklin Institute.

1842—Dec. On a modification of Lloyd's induction inclinometer. *Proc. Amer. Phil. Soc.*, ii, 237.

1843—Jan. On a new dew-point hygrometer. *Proc. Amer. Phil. Soc.*, ii, 249.

1843—May. Results of two years' observations of the magnetic elements, and of the temperature, pressure, and moisture of the atmosphere at the magnetic observatory of Girard College. *Proc. Amer. Phil. Soc.*, iii, 90.

1843—May. Account of an instrument for determining the conducting power of bodies for heat. *Proc. Amer. Phil. Soc.*, iii, 132.

1843—May. Account of observations at Philadelphia and Toronto, during the magnetic disturbance of May 6, 1843, and their bearing upon the question of the kind of instruments and observations appropriate to determine such phenomena. *Proc. Amer. Phil. Soc.*, iii, 175.

1845—Feb. Report to the Treasury Department on the progress of construction of standard weights and measures. *Senate Doc.* 149, *28th Congress, 2d Session.*

1847—Dec. Description of a new base apparatus used in the United States Coast Survey. *Proc. Amer. Phil. Soc.*, iv, 368.

1848—Dec. On a new method of observing transits. *Monthly Not. R. Astr. Soc.*, ix, 123; *Bull. Acad. Sci., Brussels*, xvi, 313; *Astr. Nachr.*, xxviii, 273.

1849—Aug. Comparison of the results obtained in geodesy by the application of the theory of least squares. *Proc. Amer. Assoc. Adv. Sci., Cambridge*, 1849, p. 102.

1849—Aug. On the progress of the survey of the coast of the United States. *Proc. Amer. Assoc., Cambridge*, 1849, p. 162.

1850—Mar. Notes on the results of observations of the direction and force of the wind at the Coast Survey stations at Mobile Point and at Cat Island, Gulf of Mexico. *Proc. Amer. Assoc., Charleston*, 1850, p. 50.

1850—Mar. Abstract of a communication on the recent progress of the telegraphic operations of the United States Coast Survey. *Proc. Amer. Assoc., Charleston*, 1850, p. 122.

1850—Aug. Method used in the Coast Survey for showing the results of current observations. *Proc. Amer. Assoc., New Haven*, 1850, p. 70; *C. S. Rep.*, 1850, p. 136.

1850—Aug. Remarks upon the meeting of the American Association at Charleston, in March, 1850. *Proc. Amer. Assoc., New Haven*, 1850, p. 159.

1850—Aug. Notes of a discussion of tidal observations, in connection with the Coast Survey, made at Cat Island, in the Gulf of Mexico. *Proc. Amer. Assoc. New Haven*, 1850, p. 281; *Amer. Journ. Sci.*, xii, 341; *C. S. Rep.*, 1851 p. 127.

1851—May. Current chart of New York Bay, from observations in the Coast Survey. *Proc. Amer. Assoc., Cincinnati*, 1851, p. 43.

1851—May. Comparison of curves showing the hourly changes of magnetic declination at Philadelphia, Toronto, and Hobarton from April to August, and from October to February, and for March and September. *Proc. Amer. Assoc., Cincinnati*, 1851, p. 62.

1851—May. On the determination of the velocity of sound by the method of coincidences. *Proc. Amer. Assoc., Cincinnati*, 1851, p. 75.

1851—May. Notes on the use of the zenith telescope in determining latitudes in the Coast Survey by Talcott's method, and on the reduction of the observations. *Proc. Amer. Assoc., Cincinnati*, 1851, p. 151; *Amer. Journ. Sci.*, xiv, 191.

1851—Aug. Additional notes of a discussion of tidal observations made in connection with the Coast Survey at Cat Island, Louisiana. *Proc. Amer. Assoc., Albany*, 1851, p. 94; *Amer. Journ. Sci.*, xiv, 346; *C. S. Rep.*, 1852, p. 111.

1851—Aug. Notes on the tides at Sand Key, near Key West, Florida. *Proc. Amer. Assoc., Albany*, 1851, p. 138.

1851—Aug. Address on retiring from the duties of president of the American Association for the Advancement of Science. *Proc. Amer. Assoc., Albany*, 1851, p. 41.

1852—Mar. Report on the harbor of Charleston, South Carolina, (as chairman of a committee.)

1853—July. On the tides at Key West, Florida, from observations made in connection with the United States Coast Survey. *Proc. Amer. Assoc., Cleveland*, 1853, p. 32; *Amer. Journ. Sci.*, xviii, 305; *C. S. Rep.*, 1853, p. 71.

1853—July. On the tides of the western coast of the United States, from observations at San Francisco, California, in connection with the United States Coast Survey. *Proc. Amer. Assoc., Cleveland*, 1853, p. 42; *Amer. Journ. Sci.*, xxi, 1; *C. S. Rep.*, 1853, p. 77.

1854—May. Preliminary determination of co-tidal lines on the Atlantic coast of the United States, from the Coast Survey tidal observations. *Proc. Amer. Assoc., Washington*, 1854, p. 107; *Amer. Journ. Sci.*, xxi, 14; *C. S. Rep.*, 1854, p. 147.

1854—May. Comparison of the diurnal inequality of the tides at San Diego, San Francisco, and Astoria, on the Pacific coast of the United States, from observations in connection with the Coast Survey. *Proc. Amer. Assoc., Washington*, 1854, p. 161; *Amer. Journ. Sci.*, xxi, 10; *C. S. Rep.*, 1854, p. 152.

1854—May. On the distribution of temperature in and near the Gulf Stream, off the coast of the United States, from observations made in the Coast Survey. *Proc. Amer. Assoc., Washington*, 1854, p. 134; *Amer. Journ. Sci.*, xxi, 29; *C. S. Rep.*, 1854, p. 156.

1854—June. Second report on the harbor of Charleston, South Carolina.

1855—Feb. Discussion of observations for the isodynamic, isogonic, and isoclinal curves of terrestrial magnetism, on and near the line of the boundary survey between the United States and Mexico, made in 1849-1852,

under the order of W. H. Emory, and combined with observations at San Francisco, California, and Dollar Point, (E. Base,) and Jupiter, Texas. *Mem. Amer. Acad. Arts and Sci.*, v, 372.

1855—Aug. Approximate co-tidal lines of the Pacific coast of the United States, from observations in the United States Coast Survey. *Proc. Amer. Assoc., Providence,* 1855, p. 144; *C. S. Rep.*, 1855, p. 338.

1855—Aug. Notice of the tidal observations made on the coast of the United States, on the Gulf of Mexico, with type-curves at the several stations, and their decomposition into the curves of diurnal and semi-diurnal tides. *Proc. Amer. Assoc., Providence,* 1855, p. 152; *Amer. Journ. Sci.*, xxi, 128; *C. S. Rep.*, 1855, p. 346.

1855—Aug. Notice of earthquake waves on the western coast of the United States on the 23d and 25th of December, 1854. *Proc. Amer. Assoc., Providence,* 1855, p. 153; *Amer. Journ. Sci.*, xxi, 37; *C. S. Rep.*, 1855, p. 342.

1855—Dec. Report to New York harbor commissioners, on surveys of New York Harbor.

1856—Jan. Annual address before the American Geographical Society, being a paper upon the Gulf Stream. *Bulletin Amer. Geogr. Soc.*, ii, 94.

1856—Aug. Approximate co-tidal lines of diurnal and semi-diurnal tides of the coast of the United States on the Gulf of Mexico. *Proc. Amer. Assoc., Albany,* 1856, p. 168; *Amer. Journ. Sci.*, xxiii, 12; *C. S. Rep.*, 1856, p. 252.

1856—Aug. On the general distribution of terrestrial magnetism in the United States, from observations made in the United States Coast Survey and others, (in connection with Mr. J. E. Hilgard.) *Proc. Amer. Assoc., Albany,* 1856, p. 187; *Amer. Journ. Sci.*, xxvi, 1; *C. S. Rep.*, 1856, p. 209.

1856—Aug. Observations to determine the cause of the increase of Sandy Hook, made by the Coast Survey for the commissioners on harbor encroachments. *Proc. Amer. Assoc., Albany,* 1856, p. 171; *Amer. Journ. Sci.*, xxiii, 16; *C. S. Rep.*, 1856, p. 263.

1856—Aug. Notice of observations to determine the progress of the tidal wave of the Hudson River, made by the Coast Survey for the commissioners on harbor encroachments. *Proc. Amer. Assoc., Albany,* 173; *Amer. Journ. Sci.*, xxiii, 17.

1856—Aug. Notes on the progress made in the Coast Survey in prediction-tables for the tides of the United States coast. *Proc. Amer. Assoc., Albany,* 1856, p. 166; *C. S. Rep.*, 1856, p. 249.

1856—Oct. Anniversary address before the American Institute of the city of New York, during the twenty-eighth annual fair. *New York,* 1857, pp. 60.

1856—Dec. Report to New York harbor commissioners on the progress of the survey of New York harbor.

1856—Dec. Notes on the winds of the coast of the United States on the Gulf of Mexico. *C. S. Rep.*, p. 272.

1856—Dec. Report of Superintendent of Weights and Measures.

1857—Aug. Notice of the determination of the longitude of Fernandina, Amelia Island, Florida, by means of chronometer exchanges from Savannah, Georgia, (in connection with Mr. C. A. Schott.) *Proc. Amer. Assoc., Montreal,* 1857, p. 166; *C. S. Rep.* 1857, p. 314.

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1859—June. Address in tribute to the memory of Humboldt. *The Pulpit and Rostrum*, No. 6.

1859—Aug. General account of the results of the discussion of the declinometer observations, made at Girard College, Philadelphia, between the years 1840 to 1845, with special reference to the eleven-year period. *Proc. Amer. Assoc., Springfield*, 1859, p. 248.

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1863—May. Abstract of results of a magnetic survey of Pennsylvania and parts of adjacent States in 1840 and 1841, with some additional results of 1843 and 1862, and a map. *Amer. Journ. Sci.*, xxxv, 359; *C. S. Rep.*, 1862, p. 212.

1863—Oct. Records and results of a magnetic survey of Pennsylvania and parts of adjacent States in 1840 and 1841, with some additional records and results of 1834, 1835, 1843, and 1862, and a map, pp. 88. *Smiths. Contrib. to Knowl.*, vol. xiii, art. viii.

1864—May. Discussion of the magnetic and meteorological observations made at the Girard College observatory, Philadelphia, in 1840 to 1845, third section, comprising Parts VII, VIII, IX. Vertical force. Investigation of the eleven (or ten) year period, and of the disturbances of the vertical component of the magnetic force, and appendix on the magnetic effect of the aurora borealis; with an investigation of the solar diurnal variation, and of the annual inequality of the vertical force, and of the lunar effect on the vertical force, the inclination and total force, pp. 72. *Smiths. Contrib. to Knowl.*, vol. xiv, art. ii; *C. S. Rep.*, 1863, p. 156.

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1844 to 1863. Annual reports of the progress of the United States Coast Survey.

1844 to 1848. Annual reports of Superintendent of Weights and Measures.

1855 to 1863. Tide tables for the use of navigators, prepared from the Coast Survey observations, annually.

Also, the following reports concerning harbors, jointly with Messrs. Totten and Davis:

1853—Mar. Report upon Cape Fear River and harbor.

1854—Oct. Report of Portland harbor commission.

1855—Mar. Second report of the commissioners on Portland harbor.

1855—Dec. Report of advisory council of the New York harbor commission. *New York Assembly Doc.*, 1856, No. 8.

1856—July. Report of the advisory council of the New York harbor commission, recommending certain lines in the East and North Rivers, and in Brooklyn. *New York Senate Doc.*, 1857, No. 40, p. 107.

1856—July. Report of the advisory council of the New York harbor commission on Gowanus Bay and its improvements. *New York Senate Doc.*, 1857, No. 40, p. 118.

1856—Sept. Report of the advisory council of the New York harbor commission on the Hell Gate Passage, regarded as a channel of approach to New York harbor. *New York Senate Doc.*, 1857, No. 40, p. 137.

1856—Oct. Second general report of the advisory council to the harbor commissioners, on lines in New York harbor. *New York Senate Doc.*, 1857, No. 40, p. 81.

1856—Dec. Report of the advisory council to the commissioners on harbor encroachments of New York, in regard to safe and commodious anchorages in New York harbor, for the purposes of the quarantine of vessels. *New York Senate Doc.*, 1857, No. 40, p. 132.

1856—Dec. Report of the advisory council to the New York harbor commissioners upon Harlem River and Spuyten Duyvil Creek. *New York Senate Doc.*, 1857, No. 40, p. 151.

1857—Feb. Report of the advisory council of lines for the East River, for the shore of Long Island, and the east shore of Staten Island. *New York Senate Doc.*, 1857, No. 126, p. 9.

1857—Mar. Report of the advisory council to the New York harbor commissioners upon the comparative map of New York Bay and harbor, and its approaches, prepared by the Coast Survey in March, 1857. *New York Senate Doc.*, 1857, No. 126, p. 12.

1860—Mar. Preliminary reports of commissioners on Boston harbor. *Boston City Doc.*, 1860, No. 37.

1860—Dec. Second report of United States commissioners on the condition of Boston harbor. *Boston City Doc.*, 1860, No. 97.

1860—Dec. Special report of the United States commissioners on Boston harbor, on the relation of Mystic Pond and River to Boston harbor. *Boston City Doc.*, 1861, No. 12.

1860—Dec. Report of the advisory council of the joint committee of the Massachusetts legislature on the subject of a ship-canal to connect Barnstable Bay and Buzzard's Bay. *Mass. Pub. Doc.*, 1864, No. 41.

1861—Sept. Fourth report of the United States commissioners on Boston harbor. *Boston City Doc.*, 1861, No. 62.

1861—Sept. Fifth report of the United States commissioners on Boston harbor. *Boston City Doc.*, 1861, No. 63.

1863—April. Sixth report of the United States commissioners on Boston harbor. *Boston City Doc.*, 1863, No. 53.

1864—Mar. Seventh report of the United States commissioners on Boston harbor. *Boston City Doc.*, 1864, No. 33.

1864—Mar. Eighth report of the United States commissioners on Boston harbor. *Boston City Doc.*, 1864, No. 34.

LECTURE ON SWITZERLAND.

By Alexander Dallas Bache.

[The following lecture on Switzerland, from the manuscript of Professor Bache, is here published for the first time to illustrate in connection with the foregoing eulogy his habit of observation and his facility of description. It presents, however, a lively sketch of one of the most interesting portions of the earth, whether considered from a historical or physical point of view, and we doubt not will be read with pleasure, especially by all who have been favored with a visit to the delightful region which it describes. The original notes from which the lecture was prepared were taken during the Professor's visit to Switzerland in 1837–'38. The foot-notes, exhibiting the present condition of the country, have been kindly furnished to us by the Hon. Mr. Hitz, Swiss consul general in this city.—J. H.]

Travelers relate that in certain conditions of the atmosphere a spectator standing upon the shore at Reggio, and looking upon the smooth waters of the Straits of Messina, sees suddenly rise before him, as if by magic, the walls, towers, palaces, domes, and streets of a city, in which mimic life goes on, men and animals moving noiselessly to and fro. The illusion is as complete as if the waters of the bay were a foundation upon which the genii of the lamp or of the ring had suddenly erected their magic structures. This is an extreme case of the ordinary illusion presented to those who, in a calm clear day, look at distant objects across a wide expanse of bay or river. Familiar forms are strangely distorted; level shores appear precipitous; the puny sloop swells into the size of a frigate; the fisherman's boat becomes a dismasted sloop, and its occupant a giant. Just so it is when in mental vision we attempt to look through an atmosphere disturbed by the habits and prejudices to which we are accustomed. Unreal towers and walls appear, and objects so lose their shapes that the most familiar forms escape recognition. Every country has its prejudices resulting from education, from all the influences, political, moral, social, and physical which surround and act upon its citizens. By these, in general, the observer of men and things is biased, and he who through the mists of *his* national or personal prejudices seeks to realize their just forms and proportions, may mistake the pigmy for a giant, the shallop for a frigate.

In estimating the institutions of the Old World we are prone to forget that the materials for our judgment are generally furnished by the opinions of those who are brought up under a totally different state of things from that which exists around us. The conclusions which we thus form may be the very opposite of those to which we would have come ourselves, had our own prepossessions furnished the inferences from the facts. In neither case, perhaps, would truth be arrived at, but in the

former the result may be deeply injurious, because leading to modes and habits of thought and action not in harmony with the peculiarities of our country.

Impressed with the importance to Americans of judging independently of the institutions of Europe, I formerly took occasion in another place to present a cursory view of the capital of Austria, as illustrating the effects of institutions the very opposite of our own. I design on this occasion to occupy your attention, without further exceeding the limits of a lecture than is absolutely necessary, by a notice of men and things in the only federated republic of Europe, Switzerland. I cannot pretend to set before you a panoramic view, but merely a few detached pictures in outline, so selected as to convey a tolerably fair idea of republican Switzerland as it appeared to an American. By contemplating it we shall have an example of the practical working of republicanism in the Old World, under various modifications, and with the disadvantages of being hemmed in on all sides by monarchies. We shall thus see the power of this system to civilize and to enlighten.

In the course of these sketches we shall find much bearing both directly and indirectly upon the objects which this Institute was established to promote. Upon the map of Europe Switzerland is so well defined by its boundaries that there is no danger of its escaping the sight on account of its small size. The Rhine constitutes nearly two sides of this boundary, from the point where the various streams from the glaciers of the Grisons have met to form a river into the lake of Constance, and from its exit thence to where the Jura Mountains turn its course to the Northern Ocean. The Jura separates Switzerland from France, and with merely an outlet for the Rhone, the Alps take up the line, dividing rugged Switzerland from the plains of Northern Italy.

The picturesque features of this country have furnished themes for the poet, the painter, and tourist. Under the influence of its snow-capped mountains, its shady and sequestered valleys, its rough glaciers, and its placid lakes, common-place men have warmed into something approaching to poetic fervor, and men of genius have poured forth their inspirations in verse or lofty prose. It is impossible to call up even in memory those scenes with all their attendant circumstances of romance—both nature and life so different from that to which we are accustomed—without feeling the heart and the imagination moved beyond their wont.

> "Who first beholds those everlasting clouds—
> Those mighty hills, so shadowy, so sublime,
> As rather to belong to heaven than earth,
> But instantly receives into his soul
> A sense, a feeling, that he loses not;
> A something, that informs him 'tis an hour
> Whence he may date henceforward and forever."

But who shall dare to speak in plain prose of scenes of which the muse of Byron has sung? The rugged nature of the country within this bound-

ary has had its effect in determining the character of institutions as well as of individuals. Small tracts of country are as completely separated by mountains of difficult passage, as by distance, differ in the modes and facilities of life, have different interests, and consequently separate organizations. The character of the topography has divided the country into many small states, and has produced striking differences in language and manners, in religions, social and political organization, in a country of not more than one-third the extent of Pennsylvania, and with about the same population of that entire State.

The present Swiss confederation consists of twenty-two sovereign states called cantons, the division of which, according to geographical position, includes also that of language.* Thus the north and middle of Switzerland contains the sixteen cantons where a dialect of the German is spoken, Zurich being the principal canton on the north, and Berne in the middle. To the west and south of the middle are the mixed German and French cantons of Neuchâtel, Friberg, and Valais; to the southeast the mixed German Romanic and Italian canton of the Grisons, or gray league, subdivided into its little sovereign states. On the southwest are the French cantons of Vaud and Geneva, and on the south of the middle the Italian canton of Tessin. While the language spoken by these people is determined by their proximity to those who speak it in its purity, their social, religious, and political institutions may almost be said to be uninfluenced by this circumstance. These are the results of other causes, many of which may be found in their history.

A Florentine scholar relating to me unpublished anecdotes of the horrors enacted by members of the far-famed family of the Medici, with Italian fervor broke out into this apostrophe: "Happy your great country, which has not the chains of a dark history to bind it to the institutions and manners of a by-gone age. Beware how you men of the present day sully the pure page which records the actions of your forefathers, of your Adams, your Franklin, your Washington."

The condition of a country at a past day must assuredly influence its present state as the summer's sun upon the snow-covered mountains of the Alps increases the autumnal flow of the river whose sources lie among them, or as the accumulation of the winter's snow upon the mountain's peak produces the summer's avalanche.

The history of the Swiss republics shows the circumstances which prepared and the impulses which gave existence to each, and a glorious history it is upon which to found progress in virtue and liberty.

Nearly in the center of Switzerland is a mountainous district which the Romans never reached, into which the bands of Attila never penetrated, and where no ruins of feudal castles exist to show that in the

* To wit: Zurich, Berne, Lucerne, Uri Schwyz, Unterwalden, (upper and lower,) Glarus, Zug, Friburg, Solerne, Basil, (city and country,) Schaffhausen, Appenzel, (both Rhodes,) St. Gallen, Grisons, Aargan, Thurgan, Tessin, Vaud, Valais, Neuchatel, and Geneva.

Middle Ages the inhabitants had a master. Divided, generally, by rocky barriers into separate communities, the people are in a degree united by the beautiful lake of the Forest cantons. These people, from the earliest records, have been, and are now, poor and pastoral. They form the democratic cantons of Schwyz, Uri, and Unterwalden, the nucleus of Swiss confederation. As early as the twelfth century they had a representative at the court of the Emperor of Germany, then the titular sovereign of Switzerland. Rudolph of Habsburg, whose castle was near the confluence of the Reuss and the Aar, the father of the founder of the house of Austria, was elected the representative of these peasants, and subsequently the family claimed the dignitary to be hereditary. This claim was never admitted, and to its impolitic enforcement by Albert of Habsburg, accompanied by circumstances of peculiar indignity on his own part, and of great cruelty and oppression on the part of his bailiff Gessler, was owing the revolution headed by Tell and his companions.

In pursuit of these same hereditary rights, Frederick of Austria, with his armies, entered the Forest cantons by their mountain passes, determined to overrun and crush them. He was successfully resisted at the pass of Morgarten by one thousand three hundred men, and nine thousand of his troops perished in this defeat. Thus was developed that fierce military spirit which has led the Swiss of every age to acts of the most devoted heroism.

From their wars with the dukes of Austria, the Swiss came out in 1412 with eight cantons recognized as independent. The appetite for war had been whetted by this successful resistance to oppression, and was carried to its height by the defeat of Charles the Bold of Burgundy, and of his magnificent troops, at Grandson and at Morat. The spoils of these great armies suddenly enriched the people. Labor was neglected and fell into contempt, and the profession of arms alone considered worthy occupation for a Swiss. The nation was for a time debased by a mercenary military spirit, and it required two centuries of bloodshed to impress the lessons necessary to their regeneration. The wars of the Reformation gave the last of this series of unhappy lessons, and at their close left the several cantons confirmed in their attachment to the same churches in behalf of which they had expended to no purpose their blood and treasure. In 1712 the confederation had attained nearly its present limits, but some of the present cantons were held as tributary provinces by the others. The Swiss spirit of former days burst forth when republican France began to proselyte by force of arms, and the constitution of the new Helvetic republic was presented at the point of the sword, and enforced by its edge. While the cantons of the plain were held by the French armies, pleasantly occupied in appropriating the savings of the aristocrats, and in giving liberty to the people by depriving them of their independence, the Forest cantons dared to declare that they had been free since the days of Tell, and Melchthal,

and Winkelried; that they required no lessons in self-government, and would resist invasion of their civil and religious rights to the death. Aloys Reding, a descendant of Rudolph, who had defeated Frederick of Austria at the pass of Morgarten five hundred years before, occupied again that Thermopylæ of his country. The mode of warfare had changed; personal strength has little advantage in contests with fire-arms; rocks and stones, though launched from mountain heights, are imperfect substitutes for cannon balls; numbers can no longer be counterbalanced by valor. Four thousand men, aided by their women and children, held this pass two days against forty thousand, but at last were forced to yield, and the Forest cantons received the constitution which they could no longer resist.

The days of the Jacobins passed; those of the First Consul and Emperor dawned, waxed, and waned, and Switzerland was the battle-ground on which the French, Austrians, and Russians contended, everywhere desolating the country with fire and sword. The pacification of Europe put an end to the horrible scenes then enacted, and the republics of Switzerland were left to reorganize themselves, affording in their rapid recovery from their desolate condition a strong evidence of the energy of the people. The organization then adopted, with some changes, exists at present. Forty years of exemption from war have obliterated the external marks of the misery of the country, but in the institutions of the different States the influence of their past history is still entirely visible.

The rough sketches which I must pass rapidly before you, to give some idea of the present condition of the country, will be taken from the French and German cantons—those which exercise the most influence upon Switzerland as it is, and as it will be.

Geneva, the oldest city of the confederation, is the frontier town upon the southwest. Its foundation dates before that of Rome itself. The inhabitants were among those Helvetians whom the fortune of war at last put at the mercy of the Romans who occupied the city with their legions. The Middle Ages found it a place of importance under the sovereignty of the Duke of Savoy; the see of a bishop, nominated by the duke, who was the temporal as well as the ecclesiastical ruler. History represents its moral and intellectual condition to have been low, its commerce moderate. Under the preaching of Farel in 1535 the citizens declared for the Reformation, and drove the bishop from their walls. In 1536, Calvin, a native of Picardy, came among them, and by his powerful preaching brought about a second reformation which changed entirely not only the face of society, but the habits and modes of thought and action of the people.

At a little distance from the water the shores of Lake Leman, or the Lake of Geneva, rise abruptly, and on this irregular ground, just where the Rhone issues from the lake, the city is built. The nature of the site thus divides Geneva into an upper and lower town. Below, and on the

steep streets occupying the slope, are the houses and shops of the tradesmen, and on the hill are those of the more wealthy citizens, once the Genevese aristocracy. The suburb on the opposite bank of the Rhone is joined by bridges to the old town, and rivals the hill-top, by its fine houses. The town is surrounded by ramparts, once of use to resist enemies and now affording pleasant promenades. These ramparts often protected the town in times gone by, but did not prevent its occupation by the French in 1798, and must necessarily yield to any enemy which has the means of bombarding the city. The conviction of their inutility has led the liberal governments of Berne and Zurich to raze these ramparts to the ground.*

The anniversary of an unsuccessful attempt, by the Savoyards, in 1602, to surprise the city, is still celebrated. Under cover of a dark night, and by the use of scaling ladders painted black the better to conceal them, a party of the enemy's pioneers had mounted the walls and penetrated into the town, when they were discovered by the careless watch. The citizens were surprised but not daunted, and issuing from their houses with such arms as they could seize, fell upon the invaders. The first gun fired from the ramparts carried away several of the scaling ladders, and prevented succor. In the morning the people assembled in the venerable church of St. Peter, when the pastor opened public worship by giving out the 124th Psalm; and since, on every 12th of December, the same sounds arise from the voices of many worshipers:

> "If it had not been the Lord who was on our side, now may Israel say:
> "If it had not been the Lord who was on our side when men rose up against us."

The University of Geneva was founded by Calvin, in 1564, and has always enjoyed a high reputation. In order to connect it advantageously with the grammar schools which prepare its pupils, the auditories have been provided, in which the character of the studies, the modes of teaching, and the discipline are intermediate between those of the school and of the university. Public instruction is under the control of the council of state, but while the impress of the best minds in this intellectual city is upon its higher institutions, the common schools are not, nor can they soon be made, what they ought to be. Like most of their fellow-republicans of the United States, the Genevese began their educational edifice at the top. They have yet to learn that parsimony in education under a popular government is waste; that unless instruction be really public it is better left entirely in the hands of individuals; that it is in vain to move the waters and then to pretend to say to the raised wave, thus far shalt thou go and no farther. The Genevese youth of families in easy circumstances find means of the best education: do they on this account effectively control those to whom the so-called republic gives less light? Witness the frequent revolutions in this city, and these not always without bloodshed. The government is founded

* The ramparts here referred to have all been removed, and Geneva at the present date (1871) presents no evidences of ever having been a fortified city.

on a popular revolution, and all attempts to impede the progress of popular institutions must in the end prove futile. If the light of education be denied to the people by their rulers, the revolutions will be bloody; and in no case can there be happiness or safety without the full exercise of popular rights, by a thoroughly educated people.*

Calvin, as head of the consistory, whose members then formed one-third of the council of state, governed Geneva, and impressed his own austere character upon the laws and manners. Public amusements were prohibited and private regulated. The number of guests to be invited to weddings of the first, second, and third class, was made the subject of municipal regulation. All dancing was interdicted, and when it was found that if the violin were played people would dance, the use of the instrument was prohibited. The absence of light amusements, together with religious feeling, naturally led to a greater use of those relaxations deemed lawful, and to the more active pursuit of science and literature by the better educated. Though times have changed in Geneva, in regard to religious creed as well as to amusements, the impress of former days is still strong upon it, and those who term it "a little Paris" do not look beneath the surface.

There is a curious mixture of the traits, manners, and modes of life of both France and England in this city, with a basis which is entirely Genevese. No less than ten thousand strangers, including, however, Swiss of other cantons, reside permanently in a town of thirty thousand inhabitants, and the number passing through it in a year is reckoned to be as great as the population itself. The influence of their manners is, of course, considerable, notwithstanding the exclusiveness of Genevese society. This exclusiveness is fostered among the ladies in the usual way, and among the men by clubs, literary, scientific, for conversation and mere amusement. It even begins among the children, who associate in little knots called Sunday societies, the members of which keep up with each other the intercourse of cousins. Many Genevese enter into commercial life abroad, and after accumulating wealth return to their home, few (except those who have migrated to the United States) becoming identified with foreign countries.

The most prominent business in Geneva is the manufacture of jewelry, and of watches. Each part of the watch is the special occupation of one class of workmen. Different portions of the works are made by peasants, but the finishing and putting together of the whole, as well as the manufacture of the cases, employ the artisans of Geneva. Nearly three thousand persons within the town, about one-fifth of the men, are occupied in the jewelers' and watch-makers' business, and twenty thousand watches are made annually.† The restrictive

* The school system of Geneva has undergone a material change, and public schools of all grades are liberally provided for.

† The census of 1870 show seven thousand persons engaged in watch-making, and upward of 200,000 watches made per annum.

duties laid upon these manufactures by neighboring countries, and especially by France, have led to a regularly organized system of smuggling, from which the government agents appear to derive a private revenue, and which is, therefore, very difficult to break up. It is said that a prefect of police of Paris, having bought at Geneva jewelry and watches to a considerable amount, the tradesman offered to deliver them in Paris for an additional sum much below the cost of carriage and the duties. The prefect made the agreement, and gave notice at the frontier custom-houses, describing the articles, and requiring even more than usual vigilance. The articles were, nevertheless, delivered to him according to contract, and on investigation he found that they had passed the frontier in his own baggage. This is one of the devious ways of trade which is, I fear, not peculiar to any nation, and which the better moral tone to be cultivated by associations like that which I now address may and should correct. To elevate the watchmakers' art, a society has been formed for the preliminary education of apprentices, and prizes for attainments in mathematics, drawing, and kindred subjects, are awarded to successful competitors.

The political changes in Geneva have been of an instructive kind. The people declared for the Reformation, and threw off the authority of the Duke of Savoy. Thus the popular will was the basis of the existence of the present government. The necessity for constant resistance to enemies without produced an easy concentration of power in the hands of a few, and by limiting the number of families from among the members of which the rulers were chosen, the government was rendered practically an aristocracy, not of rank, for the *patricians* of Geneva have always refused even this title, but of wealth and intelligence. The warfare of practice against principle has caused many revolutions, all leading to an extension of popular privileges, and though likened by the Emperor Paul, of Russia, to storms in a tumbler, their influences, direct and indirect, have spread widely. Between the year 1535, when the Bishop of Geneva was violently expelled from the city, and the year 1837, there had been five revolutions, and including two unsuccessful but violent popular commotions, and seven attempts to alter the government. And thus it must be until the end of the chapter, until privileges and rights are in harmony—until, in other words, Geneva is a true republic.

The chief points of dispute still are (unless recent events have settled some of them) that the sovereignty of the people is not formally acknowledged; that the representative council has no right to originate laws, but only to discuss those offered to them by the Council of State; that the right of petition is not recognized, and that the privilege of voting is possessed only by those who pay a certain amount of taxes; the amount being fixed so high as to exclude about two-thirds of the citizens who are over age from the polls.*

* All this has been changed by the constitution adopted May 24, 1847, the provisions whereof are essentially democratic.

Take the agitation of this canton in connection with the fact that in the eight cantons having a popular form of government, there were no revolutions in 1830, the last marked period in the progress of these governments, and the lesson becomes even more instructive.

How much do we not owe to our forefathers, who in establishing our republican system threw off the trammels of the Old World, and removed all such obstacles to our progress! How clear their view of republican institutions when compared with those of the men of Europe, even in the present day!

One of the most important engines in the improvement of Switzerland is the "Helvetic Society for public utility."* Its branches are scattered over the whole country, meeting frequently and maintaining a correspondence with the parent society through the medium of committees. Delegates from the local associations meet in different parts of the country in turn, and discuss questions connected with education, political economy, and the general welfare of the country. The reports made at these meetings and the information laid before them are printed and disseminated through the confederation by the branch societies. Independently of the influence thus exerted upon and through the reading community, the intercourse of enlightened men of different cantons is beneficial to the country, and the congregation of great and patriotic spirits has a good effect in the place of meeting. In the summer of 1837 this society met at Geneva, and then for the first time some of the statesmen of the German cantons met their fellow-citizens of the French frontier. The first meeting in the illuminated botanic garden, the mornings in the representative hall devoted to discussions, the general meetings for meals, the soirées and suppers, each served in their place, (for the Swiss, like the English, Germans, and Americans, love good cheer,) to promote the objects of the meeting. The subjects discussed in the council hall, show exactly the point to which the country has advanced. They were the importance of agricultural schools, and of schools for teachers, of saving-banks or funds, and the question whether those who in time of plenty (like the Pharaohs of old) hoard up grain to sell it at an advance in seasons of scarcity should not rather be considered benefactors of the public than objects of mob violence. The influence of high character was beautifully illustrated in one of these morning meetings. A warm debate had arisen upon the report of a committee proposing to establish schools under the direction of the society. The more the subject was discussed the further men's opinions appeared asunder. The keen politician of Geneva, with French vivacity, had made his declamation and ended with a phrase; the enthusiastic clergyman of Vaud, with somewhat of the old Calvin fire, had replied; the veteran philanthropist of St. Gall had laid down the doctrine by which he intended sturdily to abide. Union seemed impossible and discord probable, when there rose, near the president's chair, a man

* Geméinnützige Gesellschaft.

heavy in countenance and in person, with an embarrassed air and awkward address, the words of his first few sentences of miserably pronounced French coming forth slowly, and almost by stammering. The natural reflection of a stranger would have been, why does that stupid man rise; what light can he expect to throw upon the question? Not so, thought his countrymen. They knew the mind that occupied this unpromising exterior, and all listened with entire attention to Hess, the burgomaster of Zurich, while by his own moderation he stifled the flame which had been burning so fiercely, and by his good sense united all the friends of education on a common ground of conciliation and compromise. The denial of self shown by thus using a language which was not familiar to him produced, also, doubtless a favorable impression. Those who afterward heard the same speaker in his vernacular rousing an assemblage by his eloquence, or moving them to laughter by his wit, must have found it difficult to recognize in the accomplished orator the embarassed speaker of the representative chamber.

The canton of Geneva contains fifty-six thousand inhabitants, thirty thousand of whom live in the town. The adjoining canton of Vaud presents a striking contrast in this as in other respects, out of one hundred and eighty thousand people, only fourteen thousand being inhabitants of Lausanne, the capital, and only considerable town in the canton.* The people of Vaud pride themselves upon their ultra-republicanism, their orthodoxy in religion, their present moral and social condition, and the broad basis laid in their institutions for further improvement; the carrying out of the cantonal motto of "liberty and country." Their constitution declares the sovereignty of the people and the equality of all citizens in the eye of the law, guarantees individual liberty, the right of property, the inviolability of domicile, the freedom of the press, and the right of petition. It provides for the separation of the legislative, executive, and judicial authorities, a feature so universal in our constitutions that we are surprised to find it generally overlooked by the framers of the Swiss. All citizens have a right to vote at twenty-three years of age. The church is, as in all these countries, connected with the state, and is styled in the constitution the National Evangelical Reformed Church. Worship according to the forms of the Roman Catholic Church is guaranteed to some of the communes, and there this church is also connected with the state. The voluntary church system as it exists with us is almost unknown, and it would be difficult to imagine the first effects of severing church and state among a people where the connection has always existed; yet some of the clergy of Vaud look to the separation as conferring a desirable freedom upon their church. As evidences of the moral condition of Vaud may be mentioned that in 1836 there was

* The census of 1870 gives to the canton of Geneva a population of 89,416, whereof about one-half live in the city proper. According to the same authority, the canton of Vaud has a population of 229,596, and Lausanne 25,000.

but one criminal for every one thousand seven hundred and eighty inhabitants; while in Massachusetts, also an agricultural community, there was last year one criminal in one hundred and fifty; and counting only natives of the State, one in seven hundred and fifty. These people have laid broad and deep the foundations of improvement in an admirable system of public instruction, combining, as all are of one mode of faith, religious and intellectual culture. The law declares that the happiness of a people is to be found in good morals and good instruction, and that in a free country every citizen should have put within his reach an education fitting him for his rights and duties. It has not stopped at any point in public education, saying you of a certain class shall have such schools, and you such others, but has divided the schools according to the age and attainments of the children, and, for those on the threshold of active life, according to the probable future pursuit of the individual. Thus they have elementary schools, middle or industrial schools, a college, a university, and schools for male and female teachers. In a canton where suffrage is universal, the legislature has had the boldness to require that all children from the age of seven to sixteen shall be under instruction, unless capable of passing a certain examination. Parents who neglect or refuse to send their children to school are cited before the authorities and fined; in case of a repetition of the offense may be imprisoned, and thus deprived for a time of the rights of citizenship. Whether this provision can be fully executed or not yet remains to be seen; at present it is a salutary stimulus to the negligent. The ground of its adoption is, that universal suffrage requires universal education, and that as the law guarantees to citizens the one, it has a right to demand of them the other. The middle or industrial schools are colleges for business men preparing for the pursuits of commerce and the mechanic arts, and bearing the same relation to these pursuits that the colleges do to the professions of medicine, law, and theology. The canton has a school for the deaf and dumb, and one for the blind at Yverdon.

The prison discipline, like our own, puts in action the benevolent idea of reforming the delinquents; but the horror of solitary confinement which appears to exist in the mind of every one allied, even remotely, to the French has marred the system both in Lausanne and at Geneva. Happily the care which is taken in collecting the statistics of the prisons must gradually lead to a change. Finding that there are as many cases of recommitment now as under the old arrangement, they will see that with the gregarious system, even with work, there can be no reform.

This canton was the last scene of the labors of the great reformer in education, Pestalozzi. At Yverdon, on the shores of Lake Neufchatel, in a castle erected for war, but turned to purposes of peace, he terminated his active, beneficent, but stormy life. He was the Bacon of education. Adhering rigidly to the laws of induction, he changed the very basis of the sciences. He combined those extraordinary qualities

of the German character, simplicity, enthusiasm, rationalism, and its opposite, mysticism. As a practical teacher he has been surpassed by many of his followers, but he was undoubtedly the founder of a new school in education. Restless, and always dissatisfied with the results of his efforts, he began many times afresh, and to the last, with renewed hope of entire success. Unqualified to manage pecuniary matters, his mind was always oppressed with the details of the economy of his schools as soon as they became large. Prussia owes the present improved condition of her burgher or citizen schools—for her "schools for the poor"—are *poor* indeed to the precepts and examples of those who drew both from Pestalozzi. A school nominally conducted upon his principles is still kept up in the old castle, but resembles much the deformed copies from the same model which we have seen in this country.

Before leaving the southern part of Switzerland, let us pass for a few minutes into the canton of the Valais and among the Alps, not to admire scenery but to observe Swiss enterprise. Railroads are out of the question in such a country, and places for canals are rarely to be found, but improvements peculiar to the country take their places, and require both skill and originality.

In one of the narrow valleys of the Valais, a tributary to the Dranse (itself a branch of the Rhone) takes its rise in the melting snows of the glacier of Getroz. This mass of snow and ice is formed by the accumulation of snow upon two mountain flanks, which, descending and uniting in the gorge, are slowly pushed forward into the valley, melting as they advance, and feeding with innumerable rills the turbid Dranse. In the spring of 1818 the waters of the stream were very low, and as this circumstance had preceded a dreadful inundation of the valley of Bagnes in 1595, the peasants taking alarm moved up the valley to ascertain the present cause. They found that the fall of large blocks of ice from the glacier of Getroz, and of avalanches from the mountain sides, had completely dammed up the waters of the Dranse. The icy barrier is described to have been four hundred feet high, six hundred feet wide at the top, and three thousand feet at its base; the lake behind it was a mile and a quarter long, and at the barrier some fifty fathoms deep. The waters in this basin rose at the rate of two feet per day, and it was almost certain that finally, rising to a height capable of bursting the wall of ice which held them in, they would in their mighty rush sweep the valley to the very banks of the Rhone. The engineer of the canton, M. Venetz, made a bold attempt to prevent this disaster, which, if it did not entirely succeed, greatly diminished the dreaded devastation. A tunnel through the ice was commenced at a sufficient height above the swelling waters to prevent their reaching the laborers before its completion. Two sets of workmen labored day and night for nearly a month in its formation. When first finished it was not of sufficient size to prevent the rise of the lake, but widening and deepening

from the flow of water through it, in thirty-two hours it had drained off ten feet in depth of the lake, and in twenty-four hours more, twenty feet. More than one-third of the water had thus escaped when the action of the issuing cataract upon the base of the mound had so far weakened it by detaching large masses of ice, that the barrier was suddenly burst asunder. With a dreadful noise the liberated waters took their way down the valley in one mountain wave, carrying before them enormous rocks, the forest and hill-side, fields, fruit-trees and fences, bridges and châlets, and furrowing or covering the low grounds with the débris of the mountains. The destruction is represented to have been terrible, in all but that of life approaching that of the previous catastrophe. The energies of this simple people were but for a time paralyzed by this dire misfortune, and means were almost immediately taken to repair its effects and prevent its recurrence.

Captain Hall, who visited the scene just after the disaster, and again after an interval of fifteen years, thus speaks of the first appearance and of the change which industry had wrought during the interval: "We said to ourselves, that no time could ever restore their town (Martigny) to prosperity, or reclothe their fields with verdure. Yet, only fifteen years afterward, when I again visited this scene of utter, and, as it seemed, hopeless desolation, I could scarcely by any effort of the imagination recall the spot to my mind, or be persuaded that it really was the same ground I had seen laid waste. * * * * The fields were all again thickly matted with verdure; the hedges and dividing walls appeared never to have been disturbed; flower-gardens and kitchen-gardens and grass-plots smiled on every side of this happy valley; apple-trees, laden with fruit, and rows of tall poplars marked out many lines of new and better roads than before, leading from new bridges which formerly had no existence." The date of the first disaster was found inscribed upon a beam in one of the châlets, accompanied by a set of letters; the whole may be thus paraphrased: M. O. E. | 1595. | W. B. W. D. B. | T. G. O. G. The puzzle has been thus deciphered by a Swiss Monkbarns: Maurice Olliet erected, 1595, when Bagnes was destroyed by the glacier of Getroz.

Friburg lies between Vaud on the south and Berne on the north. It was the ninth canton admitted into the confederation. From having been the most aristocratic of all—some sixteen families governing seventy thousand people—it is now almost as liberal as Vaud. Suffrage is universal and the press is free. The religion of the state is Roman Catholic, the bishop still retaining the title of Bishop of Lausanne and Geneva. Party spirit, probably, run higher in this canton than in any other. The old aristocracy has its friends, though in the minority. The republicans, who triumphed in the revolution of 1830, excluded the clergy from the councils, but their influence still maintains a party there, and the church itself is divided between the rival influences of the Cordeliers and of the Jesuits. There are nine convents in the canton, a lyceum

or college and a boarding-school, in the capital. The clergy have not abandoned the claim, though deprived of the power to direct the secular instruction of the people, to license and displace their teachers. The struggles of these parties and influences keep up a constant political excitement.

It is difficult for a stranger who approaches the town of Friburg from the French cantons, on a day when the weekly fair is held, to believe that a scene of real life is before him. The old battlemented walls, with their towers, carry us back to the days of arquebusses and culverins, or even to those of cross bows and catapults. The collection of peasants in the square, clad in the varied and picturesque costumes of the adjoining districts, keeps up the illusion. It is easy to realize that such looking people should sing and dance, but that they should buy and sell in earnest is not so easily credited. There is some poetry left yet in the exterior of life, at least in these countries. This thought was again awakened on finding myself in the cell of a monk in the convent of the Cordeliers. The vaulted ceiling, grated door, bare walls, the pallet bed and rude table, with missal and crucifix, the occupant clothed in coarse black serge, the cord of his order passing around his waist, produced a most singular effect. There was nothing in the manners and conversation of the venerable Father Girard to dispel any illusion created by the circumstances around him, unless the faintest possible tinge of the world, such as he may have got while superintending the schools of his canton just after the revolution of 1814. Hoping to dull the edge of party spirit which he supposed attacked the schools because a Cordelier was at the head of them, he retired into voluntary exile for ten years, and returned, at the age of seventy-two, to die, as he said, at home, when his years would be an apology for not mingling in public affairs. He had returned to find his schools in incompetent hands, almost in decay, and his normal school, from a similar cause, on the point of being abolished. Imbued with the spirit of Pestalozzi, Father Girard gives to the languages as instruments for intellectual training the part which the great master assigned to the sciences; for economy's sake he adopted the monitorial system, but hoped to see the time when it might give place to a better. In his retirement his influence with the intelligent men of Switzerland was very great, and was exercised to forward the intellectual progress of his country. "I love all men with Christian hearts, though they may not be orthodox in formulary; such is my profession of faith," was the catholic sentiment of this truly good man, reminding me of the beautiful lines of Wordsworth, written at Friburg:

"Doom'd as we are our native dust
To wet with many a bitter shower,
It ill befits us to disdain
The altar, to deride the fane
Where patient sufferers bend, in trust,
To win a happier hour.

* * * * * *

"Where'er we roam, along the brink
Of Rhine, or by the sweeping Po,
Through Alpine vale, or champaign wide—
Whate'er we look upon—at our side
Be charity—to bid as think,
And feel—if we would know."

The situation of Friburg has afforded opportunity for two pieces of characteristic enterprise. The channel of the river Sarine forms almost a loop at the town, inclosing it on three sides, and flowing in a deep sandstone valley. The town occupies the top and sides of the promontory thus formed, and on the steep slope the tops of the houses below are on a level with the pavement of the streets above. Into this valley the road to Berne formerly descended, and mounted a precipitous hill on the other side of the stream, occupying, with its windings and the slow pace by which it was necessarily traversed, an hour, and to pass from one side of the valley to the other, a distance in a straight line of some three hundred yards. A beautiful suspension bridge now connects the upper plateau of the town with a point equally high on the opposite bank, the suspending cables of wire being firmly fastened in the massive rock on either side, and passing over two neat piers of Jura limestone. This bridge was planned by an engineer of Lyons, but executed by Swiss workmen, and entirely with Swiss materials. The road-way is eight hundred and ninety-six feet in length between the piers, or two and a half times as long as the elegant structure of the same kind now erected over the Schuylkill at Philadelphia, and once and a half as long as the celebrated chain bridge over the Menai Strait in Wales. The road-way is suspended at the height of one hundred and seventy-four feet above the Saarine, and looking up from the valley the curved wire ropes which support the whole resemble mere cords projected against the sky, while the upright wires by which the platform hangs appear like cobwebs. The trials to which this structure was subjected by the authorities before receiving it were many and severe, the hardest that of marching across it two thousand people keeping step to music, the measured cadence producing a continually increasing vibration, and trying the strength to the utmost. The successful completion of this work and its durability have led to the erection of a second of the same kind at another point of the valley; so that this little town of nine thousand inhabitants may now boast of two of the most beautiful bridges in the world.

Berne, the capital of the largest and most populous canton of the Swiss confederacy, is, in appearance, thoroughly a Swiss town of the old school. Its site is a bold promontory, like that of Friburg, nearly surrounded by the Aar, a tributary of the Rhine. The appearance of Berne is very quaint. Entering it from the south, three gateways are passed in succession, at intervals from each other, beneath towers which mark so many epochs in the extension of the walled town. Before the

use of artillery Berne was a place of great strength, the site having been selected in the twelfth century for its military properties, by Berthold, of Zähringen, the founder of the city. The fronts of the houses in the principal streets, as in the Italian towns of the Middle Ages, rest upon arcades, which form covered walks for passengers. The heavy piers of the arcades render the shops dark, but this inconvenience is more than counterbalanced by the protection from the winter's snow in a town almost among the Alps, and at an elevation of sixteen hundred feet above the sea. The streets are provided at intervals with fountains of curious devices and rude execution, in which, besides the figure of *the bear* in various "armor and attitude," are warriors and goddesses, and remarkable above all, the terror of children, the great Kinder-fresser, or ogre, who, with the head and shoulders of one poor innocent in his gaping mouth, in the very act of swallowing, has a bag full of similar choice mouthfuls about his neck, apparently struggling to escape the fate of their comrade. In one of the towers is the famous clock of kindred taste with the ogre. Before each hour a cock flaps his wings and crows a warning. A figure representing Father Time reverses his hour glass, and opens his mouth as if to cry aloud to the careless. At noon is the grand procession of the bears, who, marshaled by knights and soldiers, issue to the sound of music and pass before the figure of Time first on all fours, then half erect, and finally rampant, figuring thus the different conditions of the town of which they are the patrons. The figure now raises a wand and strikes the hour upon a mimic bell, keeping time with the striking of the clock; the cock again flaps his wings, and for twenty-four hours the bears have rest. The regard for bruin in Berne has been the growth of ages. The accidental killing of a bear by the Duke of Zähringen on the day of founding the city placed the effigy upon the coat of arms, and perhaps gave name to the infant city, for Berne signifies bear in the Swabian dialect. The effigy of the bear was connected with the conquests of the warlike burghers, and the living animal kept to amuse the people by his antics. A whimsical old lady left a handsome estate to the town to maintain a family of bears, forever, and in 1798 the animal became associated with the misfortunes of the canton as it had been with its rise and prosperity. The savings from the estate of the bears shared the fate of those of the canton, when the French armies appropriated the thirty millions of specie in the vaults of the treasury. The bears themselves were removed from their ditch and transported to Paris, the huge cage containing the father of the family having upon it the insulting inscription, not yet forgotten by the people, of Avoyer (President) of Berne. One only lived to return to his home at the general restoration of the spoils of Europe, but the bears of the present generation appear to have forgiven or forgotten the sorrows of their parents, and, all unconscious of their own present dependent state, are as diligent in climbing poles, and as active in begging and quarreling for nuts and gingerbread as if the present bear-ditch had always

been the abode of both parents and cubs. How difficult it must be for the men of Berne among the scenes of the Middle Ages, and with history and tradition both fettering them, to keep up with the progress of the times; and yet they have done so in a very great degree, as a glance at the institutions of the republic will show.

In 1785 there were but two hundred and thirty-six families, the members of which were eligible to the grand council, the governing body of a canton of three hundred thousand inhabitants, and of its tributaries, Vaud inclusive. These were the descendants of the original burghers of Berne, and of those whom they had admitted from time to time into their fraternity. Many of them were members of one of the five guilds, the bakers, butchers, tanners, smiths, and carriers, originally an aristocracy of working men. Of the two hundred and thirty-six families only seventy-six were eligible to the executive or lesser council, and twenty of these, by the preponderance of numbers, governed the State. In 1796 there were twenty-two persons of the name and family of Steiger in the grand council, fifteen of Watwyl, and so on. It was certainly no easy task to undo the Gordian knot of such institutions, but the French invasion sundered it, and the complete separation of social and political ties which followed prevented a firm reunion of the parts. A feeble aristocratic government was rëestablished under the protection of Austria, after the French occupation ceased, and was continued until 1830. At this time the revolution of the three days in Paris gave a new impulse to popular institutions by the support which it promised to hold out to their friends. The people of the country parts of Berne met in their arrondissements and petitioned the government for an extension of popular rights. They were answered by prohibiting their assembling. They continued to meet, and the government ordered out the militia to suppress these meetings, and collecting their most trustworthy troops in the town, closed the gates and prepared the cannon upon the ramparts for action against the peasantry. The militia refused to turn out; the troops in the town declared their unwillingness to act against their countrymen. No attack was made, but the government wisely determined on abdication, declaring that on a certain day they would cease their functions if such was the will of the people. This was all that was desired. An assembly was called to frame a constitution, and without any violent shock, in October, 1831, the old aristocratic government gave place to the new republican, in which although there is some leaven of the former aristocracy, it is not sufficient to leaven the lump. This is a true history of a Swiss republican revolution. The new constitution declares the sovereignty of the people, the liberty of the press, the right of the representative council to originate measures, toleration of religion with an established national church. Every citizen is an elector of the first grade; and every hundred of them chooses an elector of the second grade, who votes for the representative council. As in the other cantons, with few exceptions, the

powers of government are mingled, and what strikes an American as even more strange, while the representative council is elected for six years, the judges chosen by them are elected but for five.

One of the first steps of the new government was to reorganize and renovate public instruction. A visit to the normal school established by them must inspire bright anticipations of future improvement for the country. Patriotism, religious and moral feeling, and intelligence, are developed by precept and example in those who are hereafter to have the training of the Bernese youth. The industrious life of these future teachers, eleven hours being spent in the school-room, in receiving or imparting instruction, their frugal fare, meat of any kind being placed before them but twice in each week, and their coarse clothing, are all shared with them by the director of the institution. Severe exercise in the open air, through the gymnastics so popular in Germany and Switzerland, counteracts, in a degree, the effect of this sedentary life upon their health. In addition to the branches usually cultivated in our schools, music is made a part of the teacher's education, that he may, in turn, give instruction in it to all his pupils. The effect produced by the deep toned and well tuned voices of the young teachers in this normal school, engaged in singing, *con amore*, some of the patriotic songs of their country, was one of the most moving that I ever experienced. What a fine material for republicans! was the remark of the counsellor of state who accompanied me, the echo of the very feeling which was thrilling through me. Close by this school is Hofwyl, the celebrated institution of Emmanuel Fellenberg. But to venture within its precincts would occupy you far longer than I am privileged to do. The system of this establishment, for it is not one school, but is composed of several schools of different grades, has served, in a degree, as a model for that of the canton, and has exerted a greater influence in and out of Switzerland than any other single institution in the world.

The new government has reorganized and improved many of the public establishments of the canton, and created new ones. Thus the two orphan houses of the city have already felt its favorable influence; a school for the deaf and dumb, and one for the blind, has been established under its patronage, and a new penitentiary has been erected for the introduction of the modern improvements in prison discipline. In 1819 women condemned for crimes swept the streets of Berne, and now the government is nearly prepared to adopt the Pennsylvania system of prison discipline. Surely the progress of this people has been worthy of, if not above, all praise.

On the eastern side of the town the bank of the Aar is quite precipitous, and from the parapet which crowns it a glimpse is had into that fairy-land, the Oberland of Berne. The peaks of its snow-clad hills, with their bold outline, cut sharply against the sky, presenting, in the course of a clear day, a beautiful variety of aspect, from the dark shadows cast by the rising sun, and the brilliancy of mid-day, to the delicate hues at

sunset, and the ashy and almost ghastly paleness of the evening. One of the few things which cannot disappoint is a visit to the Bernese Alps. Nature presents itself not only upon a grand scale, but in unusual and varied forms. Lofty and precipitous mountains, rugged with rocks, and ice, and snow; glaciers pushing their way from the steep mountain sides into the valleys; avalanches tumbling headlong from the heights, and with a roar like distant thunder burying their ice and snow in the deep gorges; cascades pouring from precipices so lofty that the water is dispersed in dust-like spray, in mid-air, or tumbling from rock to rock in foaming sheets; pine-clad hills, and valleys green with grass; all these, in turn, rejoice the sight, while the unaccustomed modes of Alpine traveling invigorate the frame, and the spirits rise until they create a world of enjoyment of their own. The works of man lend themselves to nature, to add to the picturesque character of these regions; for the Swiss cottage, with its roof weighted with stones, its projecting eaves and out-door galleries, is unlike a farm-house elsewhere, and the châlet, with its stable, dwelling, and dairy, all under one roof, yet separated with scrupulous regard to neatness, is as unlike a peasant's hut. The costume of the people, too, puts them to the eye of a stranger in constant masquerade, and the vocal music, with its curious falsetto tones, and the instrumental upon the wooden tube, or Alpine horn, are unlike what is to be heard in other countries.

The valley of Grindelwald is itself more than three thousand feet above the level of the sea, and from it the Faulhorn rises three thousand more. The ascent of this mountain is by winding paths, along the base or on the brink of high rocks, by the side of ponds formed by the melting snow, through the snows themselves, to the very apex. Then the whole district of the lakes of Brientz and Thun is stretched out before and far below you, the lake of Lucerne and its mountains, the valleys of Lauterbrunnen and Grindelwald, the Alpine heights of the Eiger, the Monk, the Jungfrau, and others of this chain, far across to the mountains where the Rhine and the Rhone both have their sources. Above the region where the white hill-clouds of summer are formed and rest, when *they* occur spreading a deep shade over the valleys below, the top of the Faulhorn is in the full blaze of the sun, and the eye ranges from it upon the expanse of the tops of the white clouds, as over a vast plain of snow thrown into ridges by the wind, a mimic ocean of snow with the forms of waves without their motion. Life in a châlet upon such a mountain is very little like that in an inn down in the valley. The whole mountain-top will hardly give elbow-room to the twenty or thirty people who come up on a fine summer's day, much less will the châlet give room for exclusiveness in eating, drinking, or sleeping. Then, further, to break down reserve, the sunset is to be seen by all, and then the moon, at rising or setting, puts the whole sleeping household in motion, and again all are out to see the sun rise over the distant Alps.

There are some traits by which one may infallibly recognize our coun-

trymen, and in this châlet with us was an undoubted American. He talked to every one who could speak his vernacular, and spoke to every one who would give his broken French an answer. His meals were bolted down in haste. He fidgeted lest he should lose anything of the moon or sun rise, and actually turned out to witness the former in regular Kickapoo style, wrapped in a blanket. He was restless to an excess, and talked all the time that others were absorbed in sentiment; forgetting his unpresentable condition, he even addressed some young English ladies, who had certainly offered no special encouragement to the approach of any fellow-traveller, even in full costume. He was off among the first in the morning, and after the day's journey we met him in the evening at Meyringen, still talkative as ever, and his tones certifying that he came from the east of the Hudson; so far, the very beau-ideal of the American figured by tourists. Here, however, he piqued my curiosity by the very un-American act of abusing the supper, as well as by some peculiarity of expression; and, entering into further conversation with him, I found that this *undoubted* American was last from Thread and Needle street, had been born and bred in the old country, and had not even trodden our republican soil. So much for national characteristics, which, like family peculiarities, may sometimes lead us to mistake the father for the son.

On the way from the Oberland to Lucerne we pass a work of improvement well worthy of notice. At the foot of the Brunig Mountain, on the north side, is the small lake of Lungern, draining the slopes of a basin of moderate extent, and having originally no outlet. It is separated by a mountain ridge from the lake of Sarnen, which communicates with the lake of Lucerne. Lake Lungern is some four hundred feet higher than Lake Sarnen, so that by establishing a communication between them the former might be drained to any required amount, and arable land be thus gained upon the lake shore. A tunnel to establish this connection was begun in 1788, and after many delays was completed in 1836, at the cost of $25,000, and nineteen thousand days' work by the peasants. The winter season, when the lake is lowest, was chosen for completing the tunnel by breaking through a rocky barrier into Lake Lungern. The undertaking succeeded, and in ten days the water fell to the level of the mouth of the tunnel. A new and unforeseen danger now threatened the people of the village on the lake shore. The bank, no longer supported by the water, and exposed to the action of the frost, began to crack, and the earth separating from the underlying rock, threatened to precipitate the church and part of the village into the lake. In fact a slide did take place, but only to a limited extent, and by cutting the shores in terraces the progress of the evil has been stopped, and the gain of about five hundred acres of arable land may be considered as permanent.

The town of Lucerne, the capital of the canton of the same name, and formerly in rotation with Berne and Zurich, the seat of the sessions of the

Swiss Diet, is beautifully situated on the lake of the Forest cantons, on a level piece of ground, at the point where the Reuss issues from the lake to join the Limmat in its course to the Rhine. Lucerne, on a gala day, presents an interesting sight to the stranger. When I saw it, the people in holiday dress were collecting from all quarters to the lake side; the long wooden bridges which join the different parts of the town, and the stone-lined quays along the Reuss, were thronged with people pressing toward the same point. The women from the country wearing the hair plaited on the crown of the head, or black caps with mohair lace wings, and long plaits of hair and black ribbons falling down the back, accompanied by men in plain attire, all speaking the harsh patois derived from the Southern German. Even the bridge from the Abbey had its passengers, though now few indeed in numbers, and a few Cordeliers were seen mingling with the throng. The windows of the tall houses near the wharf presented an array of the notables of Lucerne, and even some members of the diet might be pointed out to the stranger. The bells were ringing at intervals, and cannon pointed toward the lake were prepared for a salute. The American smiles complacently when told the cause of all this circumstance. The first steamboat navigating the lake is expected on its first return trip from Altdorf, and even now may be seen rounding a neighboring point. The excitement increases as the wonderful boat approaches, and we are carried in imagination back to the days of 1807, when New York poured out its population to greet the return of the first adventure of the great Fulton. No doubt now mingles, as then it did, with expectation, and amid the hoarse noise of loud German exclamations and hurrahs, and the discharge of artillery, the boat approaches. It is wonderful to see how at once the art of managing the vessel has been acquired! How imitative a creature man is! The captain is mounted upon the wheel-guard directing the pilot and engineer with his hand. The headway is checked judiciously, and now the boat nears the wharf. With what precision and skill this manœuvre is executed for the first time! The thought is hardly complete, when rising loud and clear above the hoarse gutturals of the mob, comes to do away all mystery, to explain the whole, in good homespun English, the well-known cry of "Stop her!" The engine was built in England, put up by Englishmen, and is now managed in its first trial by them; and thus the mechanics and manufacturers of that great nation lay not only Switzerland, but all the continent of Europe, under contribution, as a return for the money spent abroad by her travelers.

The Swiss Confederacy is, politically considered, even a weaker government than ours was under the old Articles of Confederation; at all events weaker for every purpose not merely military. The act of confederation now in force dates from 1815, and all the attempts made since its adoption to modify it so as to produce a stronger government, by cementing the union more closely, have failed. The cantonal spirit resists the least encroachments upon its independence. The act of con-

federation guarantees to each canton its liberty, its independence, its safety from foreign aggression, and peace and tranquillity within. To maintain this guarantee and to preserve the armed neutrality of Switzerland, a contingent of 33,000 men and $140,000 is required from the cantons in proportion to their population and other circumstances. The modified constitution declared every Swiss to be a soldier, expressing only what is the fact, the military spirit being kept constantly alive from the belief that it is essential to the independence of the country. In case of the invasion of a canton, or of violence against the actual government, the confederation is bound, upon a summons, to an armed intervention; and, in case of necessity, a neighboring canton may lend its aid. This provision has been a fertile source of difficulty, for on the one hand the cantons claim the right of revolution, and, on the other, the diet that of intervention. The cantons have no right to form leagues with each other. No privileged classes may be established in any of them. The transit of articles of merchandise and manufactures, and of the necessaries of life, through the different cantons is guaranteed. Such are the leading articles of the constitution.

The diet is the highest authority of the confederacy, and consists of deputies from the twenty-two cantons, who vote, unless specially invested with discretionary power, according to instructions derived from the cantonal governments. Each canton has one vote in the diet. The regular meetings of this body are held yearly, and the senior deputy of the canton where the meeting is held presides. Executive power during the recess of the diet may be vested in the authorities of the canton where the meeting of the year is to be held, or in a special executive council. The diet declares war and makes treaties of peace and alliance; such measures requiring a majority of three-fourths of the votes.*

In the summer of 1837 the diet met at Lucerne. The stormy session of the year before at Berne, in which they had borne themselves so gallantly in opposition to the demands of France, was still fresh in the recollection; but with the adjustment of the difficulties the excitement produced by them had subsided. On that occasion it was said that Switzerland had spoken even in a boasting tone, or, in the language of the French journalists, as if she were a first-rate power instead of a fourth. The national feeling which dictated this tone may be explained and felt by the remark of Professor Monnard, of Vaud, by whom the

* The foregoing remarks apply to the political condition of the Swiss Confederation previous to the 12th of September, 1848, when the revised federal constitution now in force was adopted. This instrument is very similar to that of the United States, only paying somewhat more deference to states rights, and vesting the executive power in a cabinet (federal council) elected by congress in joint session, the chairman whereof being denominated President of Switzerland. The legislative authority is vested in a federal assembly, (congress,) composed of a national council (house of representatives) and a staenderath or States council, (senate;) the supreme court and executive authority being both elected by the federal assembly or congress, in joint session, in which is vested the supreme power of the land. Berne is the permanent capital.

threatening language was spoken, "we cannot recognize a first-rate and a second-rate national honor."

There is still something of the "feudalism of democracy," as a distinguished author has called it, in the ceremonies of the diet, walking in procession to their hall where their deliberations take place, wearing cloaks embroided with the arms of their cantons, and even of more than one color, received by double rows of guards, and deliberating with swords by their sides. The antiquated costumes are destined to disappear with many feudal forms, but the delegates from those cantons, the democratic, where the least change has taken place in their institutions, are wedded to their old garments as well as to the old constitution. In the hall of meeting twenty-one seats are arranged about an oval table for the senior representatives, the president having his seat at the one extremity of the table, and the consulting deputies occupying small tables in the rear. The members do not rise when addressing the chair, which has an awkward effect, and must be embarrassing to the lively delegates of the Italian and French cantons; but all minor embarrassments yield to that of the use of three different languages, the French, German, and Italian, by members from the different cantons, while a majority of the deputies understand but one. A glance at these representatives will illustrate the difficulties of forming a Swiss union. What has the man of Tessin really in common with him of Geneva? The one is a Roman Catholic, the other a Calvinist; the one a republican of the most democratic school, the other an aristocrat by principle, and perhaps by birth; the one is from a rough pastoral or agricultural district, the other from a city where the more refined mechanic arts flourish; the one from a small community, all the members of which are nearly equal in the means of life and in education, the other from a town where wealth and education are very unequally distributed; the one in speech an Italian, the other a Frenchman. Again, what has the educated and polished professor of Lausanne, or the merchant and banker of Basle, in common with the peasant of Appenzele or the shepherd of Uri? With all these diversities they are brought together in part by a sentiment—the love of liberty; in part by a necessity—that of mutual defense. The progress of the cantons in education and the arts of life will doubtless draw their bonds gradually closer, and to have attempted a union in 1832 is to have laid the basis for it at some other time. Meanwhile the confederation, if it does not directly aid the cantons in their career of improvement, at least goes far to guarantee the continuation of that peace which is essential to progress.

Let us turn our backs upon the mountains, to glance merely, for that is all that can be attempted, at Zurich, one of the cantons of the plain, if any part of Switzerland can be called a plain; one of the farthest advanced of all in the mechanic arts, manufactures, education, and good government. Here the republican change was brought about in 1830, by a simple change of administration, the council not being required to

abdicate as at Berne, and up to this time a struggle for power goes on between the partisans of a former order of things and the clergy against the new order, and, from time to time, one or the other influence prevails. The canton, meanwhile, steadily advances. Suffrage is universal; the right to vote beginning at twenty years of age.

The progress of the canton since the new order of things may be best illustrated by a few facts. The press is free, the legislative, executive, and judicial departments have been separated, public instruction has been set forth as one of the first duties of the state, and invasion of domicile has been declared unlawful. To these intellectual improvements may be added physical or material ones; good roads have been made throughout the canton and stage coaches put upon them, so that instead of ten or twelve people leaving Zurich, or entering it, per day, there are now one hundred and ten. The poor tax is at the rate of but 5 cents per annum for each citizen inhabiting the canton; the church rate 18 cents; and the expense of the civil list 20 cents. Finally the revenue in 1832 exceeded the expenditure by $100,000, and this surplus has been devoted to the cause of material and intellectual improvement.

From the hasty and imperfect glance which we have now taken together of republican Switzerland, what conclusion may we draw as to the capacity of the principle which connects these people, to produce their happiness, their moral, intellectual, and physical improvement?

In the distance which separates us from them the minuter shades of character are lost. We do not discern the men of Geneva, of Vaud, of Berne, and of Zurich, but the men of Switzerland. Standing out from the picture, like the lofty summits of their own mountain chains, are the prominent characteristics of the people. Frugality, perseverance, hardy enterprise, high moral and religious feeling, lofty patriotism; these are the characteristics of the Swiss nation.

How far these noble qualities are the result of their political institutions, or whether the institutions owe their origin to these very qualities of the people, it is needless to inquire, since what greater praise can be awarded than the truth, that the institutions of Switzerland are in harmony with the free spirit of the people, and the spirit of the people with their noble republican institutions.

ON A PHYSICAL OBSERVATORY.

By Prof. Joseph Henry.

Smithsonian Institution,
Washington, December 29, 1870.

My Dear Sir: Yours of the 28th of November was duly received, but I delayed answering it until the pressure of business which accumulated during my absence should have somewhat subsided, and, also, that I might receive the plans which you mention. I am now gratified in being able to inform you that my visit to Europe was both pleasant and profitable, and that I have returned much improved in health and with enlarged views as to the present state of science in the Old World.

While abroad I gave special attention to physical observatories, of which there are several in England and on the continent, although there is no one which fully realizes my idea of what such an establishment ought to be.

A physical observatory is one the primary object of which is to investigate the physical phenomena of the earth and the heavenly bodies in contradistinction to an ordinary astronomical observatory, which is principally devoted to the observation and discussion of the motions of the planets, and the determination of the relative positions of the fixed stars. Of the latter kind but one or two are needed in any country, and as these require a numerous corps of observers and computers they can only be supported by appropriations annually from a national government. The United States Observatory at Washington is of this character, and, including all expenses, requires an annual appropriation of at least $59,000. The labors of such an observatory are indispensable to the advancement of the science of theoretical astronomy, and its application to geodesy and geography.

The establishment I would advise you to found is of the character of the one first mentioned, namely, a physical observatory, the principal object of which would be, as I have indicated, to investigate the nature and changes of the constitution of the heavenly bodies; to study the various emanations from these in comparison with the results of experiments, and to record and investigate the different phenomena which are included under the general term of terrestrial physics.

A wide field has been opened for the study of the nature of the sun and other heavenly bodies by the application of the spectroscope, different modifications of the telescope, and other lately invented appliances. We now know that the sun is undergoing remarkable changes, the character of which can only be ascertained by the results of accurate observations compared with those of experimental investigation. The observer

should divide his attention between the phenomena revealed by a critical and continued examination of the sun and the production of similar phenomena in the laboratory. In this way European investigators have arrived at most interesting results.

Again, we know that the emanations from the sun, and probably from the stars, differ essentially in character. There is, first, the emanation known as light, which of itself consists of various rays, which generally indicate the incandescence of substances, which give the sensation of different colors, and those which, in their ordinary condition, are imperceptible to the eye, but which may be perceived by that organ after they have passed through certain liquids; next, the heat emanation, which is also of different kinds; then the chemical emanation, by which photographic impressions are produced; and, lastly, the phosphorogenic emanation, which abounds also in the electric discharge, and which produces the glow of the diamond and the luminosity of the compounds of lime, barium, and other substances with sulphur. To study these or other emanations as they may appear in the fixed stars, or are reflected from the moon and planets, or as they may be found in the aurora borealis, the zodiacal light, and in shooting-stars or larger meteors, requires peculiar instruments, and such as are not found, at present, in ordinary astronomical observatories. For example, the celestial phenomena which address themselves to the sense of sight are studied by means of refracting telescopes, as are, also, those of the photographic ray, although this requires a peculiar form of lens, while the heat-ray of lower intensity and the phosphorogenic ray are not transmitted by glass; the former is readily converged to a focus by a lens of rock-salt, and the latter by one of quartz. They may all, however, as in the case of light, be concentrated into foci by metallic reflectors.

In regard to terrestrial physics, the phenomena are also various, and the forces by which they are produced are constantly changing both in intensity and, in some cases, in direction. We now know that the magnetism of the earth scarcely remains the same from one moment to another, and that these changes are connected with the appearance of the aurora borealis and electrical discharges in the atmosphere. They, also, in all probability, may ultimately be referred to disturbances produced by external influences, such as those from the sun, moon, and planets. Furthermore, we may now consider the whole earth as an immense conductor charged with negative electricity, of which the intensity is in a continued state of change, and of which a knowledge of the laws, as well as those of the changes of magnetism, is highly desirable. For the proper study of these, continuous self-recording instruments are necessary.

There is also an important field of observation in regard to ordinary meteorology, such as the changes of the pressure of the atmosphere, and its connection with other phenomena; of the normal and abnormal winds; isolated currents of the atmosphere, and especially those of a

vertical direction; the radiation of heat from clouds and different terrestrial surfaces; the variation of its intensity in ascending above and penetrating below the surface of the earth, &c. In short, the field is almost boundless, and every year reveals new facts in terrestrial and celestial physics, which never fail to furnish new points for investigation to those who are qualified by education and endowed by nature for their proper appreciation.

The conductor of an observatory, such as I have mentioned, to be successful, must have peculiar characteristics. He must possess a minute knowledge of all the latest discoveries in physics, a keen eye to detect new appearances, imagination to suggest hypothetical causes, logical power to deduce consequences from these to be tested by observation or experiment, and ingenuity to devise apparatus for verifying or disproving his deductions. When *such* a man is found he should be consecrated to science and fully furnished with all the implements necessary for the prosecution of his researches, those of physics as well as of astronomy, and himself and family placed beyond all anxiety as to the supply of their necessary wants. It may not be amiss to combine with his studies and duties, in the way of research, a small amount of lecturing—just enough by sympathetic communication with admiring pupils to fan, as it were, his enthusiasm, and to impart a portion of it to others. He should also have at his command a skillful workman, who, under his direction, could construct the temporary apparatus which are constantly required in original research. It is also important that he be associated with the faculty of a well-endowed college or university, to which he will become an important acquisition both in regard to the reputation which he will give to the institution, and the effect he will have on the other members of the faculty in the way of stimulating them to higher efforts. In such an association he can call for the coöperation of the professors, and especially that of the physicist, the chemist, and the mathematician.

One of the most important points, perhaps, to which I should call your attention is that of the building to be erected, since, from the tendency to error in this line, more injury has resulted to public institutions in this country than from any other cause. It should be recollected that "money is power;" that every dollar possesses a definite amount of potential energy, as it were, which can always command intellectual or physical labor. But money as a power is unlike all other kinds of power, in that it is, by judicious investment, capable of yielding a constant supply of energy, in the way of interest, without diminishing the original amount. It is, therefore, in the highest degree injudicious in the founding of an establishment to exhaust the source of its power by architectural displays not absolutely required, and which may forever involve a continual expense from the remaining funds to keep them in repair. As a general rule, the buildings of educational or scientific institutions should be gradually evolved from the experience and wants

of the establishment, and not, as is too frequently the case, from *a priori* misconceptions of those who have no adequate idea of the uses to which the structure is to be applied. It should be impressed upon the public that *buildings* do not constitute an institution, and that reputation and usefulness in science do not flow from visible and tangible manifestations, but are the immaterial fruit produced by the spirit of an organization. I trust that millions of human beings yet unborn will be familiar with the intellectual results of your observatory, although a single inquiry may never be made as to the style of the building in which these results have been produced.

My advice, then, would be: first, if possible, that the right man be procured for director; secondly, that the principal instruments be constructed under his supervision; and, thirdly, that the operations be commenced in an inexpensive wooden building, which will be found better in many respects for physical and astronomical observations than one of stone and brick. The instruments could be insured, I should think, at a small premium, and in that case, if destroyed by fire, might be replaced by others embracing the improvements which may have been suggested in the mean time.

As an illustration of what I have just said in regard to the building, I may mention that in a visit to Mr. Lockyer I found him carrying on a series of observations which have challenged the admiration of the world in a temporary structure made of rough boards, unplastered, and scarcely including a space of fifteen feet square.

As to the location of your observatory, you will infer from what I have said that I think it important to connect it with some well-endowed and well-established college or university.

JOSEPH HENRY,
Secretary Smithsonian Institution.

To —— ——.

THE HISTORY OF MY YOUTH: AN AUTOBIOGRAPHY OF FRANCIS ARAGO.

[To keep up the series of publications of eulogies of distinguished men, which has been a special feature of the Appendix to the Smithsonian Reports, the following autobiography and the eulogies of Herschel and Fourier are copied from the volume, now out of print, of the translations by the late Admiral Smyth, the late Rev. Baden Powell, and Prof. Grant, from the works of Arago.—J. H]

I have not the foolish vanity to imagine that any one, even a short time hence, will have the curiosity to find out how my first education was given, and how my mind was developed; but some biographers, writing off-hand and without authority, having given details on this subject utterly incorrect, and of a nature to imply negligence on the part of my parents, I consider myself bound to put them right.

I was born on the 26th of February, 1786, in the commune of Estagel, an ancient province of Roussillon, (department of the Eastern Pyrenees.) My father, a licentiate in law, had some little property in arable land, in vineyards, and in plantations of olive trees, the income from which supported his numerous family.

I was thus three years old in 1789, four years old in 1790, five years in 1791, six years in 1792, and seven years old in 1793, &c.

The reader has now himself the means of judging whether, as has been said, and even stated in print, I had a hand in the excesses of our first revolution.

My parents sent me to the primary school in Estagel, where I learned the rudiments of reading and writing. I received, besides, in my father's house, some private lessons in vocal music. I was not otherwise either more or less advanced than other children of my age. I enter into these details merely to show how much mistaken are those who have printed that at the age of fourteen or fifteen years I had not yet learned to read.

Estagel was a halting place for a portion of the troops who, coming from the interior, either went on to Perpignan, or repaired direct to the army of the Pyrenees. My parents' house was therefore constantly full of officers and soldiers. This, joined to the lively excitement which the Spanish invasion had produced within me, inspired me with such decided military tastes that my family was obliged to have me narrowly watched to prevent my joining by stealth the soldiers who left Estagel. It often happened that they caught me at a league's distance from the village, already on my way with the troops.

On one occasion these warlike tastes had nearly cost me dear. It was the night of the battle of Peires-Tortes. The Spanish troops in their retreat had partly mistaken their road. I was in the square of the vil-

lage before daybreak. I saw a brigadier and five troopers come up, who, at the sight of the tree of liberty, called out, "*Somos perdidos!*" I ran immediately to the house to arm myself with a lance which had been left there by a soldier of the *levée en masse*, and placing myself in ambush at the corner of a street, I struck with a blow of this weapon the brigadier placed at the head of the party. The wound was not dangerous. A cut of the saber, however, was descending to punish my hardihood, when some countrymen came to my aid, and, armed with forks, overturned the five cavaliers from their saddles, and made them prisoners. I was then seven years old.*

My father having gone to reside at Perpignan, as treasurer of the mint, all the family quitted Estagel to follow him there. I was then placed as an outdoor pupil at the municipal college of the town, where I occupied myself almost exclusively with my literary studies. Our classic authors had become the objects of my favorite reading. But the direction of my ideas became changed all at once by a singular circumstance which I will relate.

Walking one day on the ramparts of the town, I saw an officer of engineers who was directing the execution of the repairs. This officer, M. Cressac, was very young. I had the hardihood to approach him and to ask him how he had succeeded in so soon wearing an epaulette. "I come from the Polytechnic School," he answered. "What school is that?" "It is a school which one enters by an examination." "Is much expected of the candidates?" "You will see it in the programme which the government sends every year to the departmental administration; you will find it moreover in the numbers of the journal of the school, which are in the library of the central school."

I ran at once to the library, and there, for the first time, I read the programme of the knowledge required in the candidates.

From this moment I abandoned the classes of the central school, where I was taught to admire Corneille, Racine, La Fontaine, Molière, and attended only the mathematical course. This course was intrusted to a retired ecclesiastic, the Abbé Verdier, a very respectable man, but whose knowledge went no farther than the elementary course of La Caille. I saw at a glance that M. Verdier's lessons would not be sufficient to secure my admission to the Polytechnic School; I therefore decided on studying by myself the newest works, which I sent for from Paris. These were those of Legendre, Lacroix, and Garnier. In going through these works I often met with difficulties which exceeded my powers; happily, strange though it be, and perhaps without example in all the rest of France, there was a proprietor at Estagel, M. Raynal, who made the study of the higher mathematics his recreation. It was in his kitchen, while giving orders to numerous domestics for the labors of

* With such precocious heroism it is by no means so clear that the author might not have had a hand in the revolution, from which he endeavors above to exculpate himself.

the next day, that M. Raynal read with advantage the "Hydraulic Architecture" of Prony, the "Mécanique Analytique," and the "Mécanique Céleste." This excellent man often gave me useful advice; but I must say that I found my real master in the cover of M. Garnier's "Treatise on Algebra." This cover consisted of a printed leaf, on the outside of which blue paper was pasted. The reading of the page not covered made me desirous to know what the blue paper hid from me. I took off this paper carefully, having first damped it, and was able to read underneath it the advice given by d'Alembert to a young man who communicated to him the difficulties which he met with in his studies: "Go on, sir, go on, and conviction will come to you."

This gave me a gleam of light; instead of persisting in attempts to comprehend at first sight the propositions before me, I admitted their truth provisionally. I went on farther, and was quite surprised, on the morrow, that I comprehended perfectly what over-night appeared to me to be encompassed with thick clouds.

I thus made myself master, in a year and a half, of all the subjects contained in the programme for admission, and I went to Montpellier to undergo the examination. I was then sixteen years of age. M. Monge, jr., the examiner, was detained at Toulouse by indisposition, and wrote to the candidates assembled at Montpellier that he would examine them in Paris. I was myself too unwell to undertake so long a journey, and I returned to Perpignan.

There I listened for a moment to the solicitations of my family, who pressed me to renounce the prospects which the Polytechnic School opened. But my taste for mathematical studies soon carried the day. I increased my library with Euler's "Introduction à l'Analyse Infinitésimale," with the "Résolution des Equations Numériques," with Lagrange's "Théorie des Fonctions Analytiques," and "Mécanique Analytique," and finally with Laplace's "Mécanique Céleste." I gave myself up with great ardor to the study of these books. From the journal of the Polytechnic School, containing such investigations as those of M. Poisson on Elimination, I imagined that all the pupils were as much advanced as this geometer, and that it would be necessary to rise to this height to succeed.

From this moment I prepared myself for the artillery service, the aim of my ambition; and as I had heard that an officer ought to understand music, fencing, and dancing, I devoted the first hours of each day to the cultivation of these accomplishments.

The rest of the time I was seen walking in the moats of the citadel of Perpignan, seeking by more or less forced transitions to pass from one question to another, so as to be sure of being able to show the examiner how far my studies had been carried.*

* Méchain, member of the Academy of Sciences and of the Institute, was charged in 1792 with the prolongation of the measure of the arc of the meridian in Spain, as far as Barcelona.

During his operations in the Pyrenees, in 1794, he had known my father, who was

At last the moment of examination arrived, and I went to Toulouse in company with a candidate who had studied at the public college. It was the first time that pupils from Perpignan had appeared at the competition. My intimidated comrade was completely discomfited. When I repaired after him to the board, a very singular conversation took place between M. Monge, the examiner, and me.

"If you are going to answer like your comrade, it is useless for me to question you."

"Sir, my comrade knows much more than he has shown; I hope I shall be more fortunate than he; but what you have just said to me might well intimidate me and deprive me of all my powers."

"Timidity is always the excuse of the ignorant; it is to save you from the shame of a defeat that I make you the proposal of not examining you."

"I know of no greater shame than that which you now inflict upon me. Will you be so good as to question me? It is your duty."

"You carry yourself very high, sir; we shall see presently whether this be a legitimate pride."

"Proceed, sir; I wait for you."

M. Monge then put to me a geometrical question, which I answered in such a way as to diminish his prejudices. From this he passed on to a question in algebra, to the resolution of a numerical equation. I had the work of Lagrange at my fingers' ends; I analyzed all the known methods, pointing out their advantages and defects; Newton's method, the method of recurring series, the method of depression, the method of continued fractions; all were passed in review; the answer had lasted an entire hour. Monge, brought over now to feelings of great kindness, said to me, "I could, from this moment, consider the examination at an end. I will, however, for my own pleasure, ask you two more questions. What are the relations of a curved line to the straight line which is a tangent to it?" I looked upon this question as a particular

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one of the administrators of thedepartment of the Eastern Pyrenees. Later, in 1803, when the question was agitated as to the continuation of the measure of the meridian line as far as the Balearic Islands, M. Méchain went again to Perpignan, and came to pay my father a visit. As I was about setting off to undergo the examination for admission at the Polytechnic School, my father ventured to ask him whether he could not recommend me to M. Monge. "Willingly," answered he; "but, with the frankness which is my characteristic, I ought not to leave you unaware that it appears to me improbable that your son, left to himself, can have rendered himself completely master of the subjects of which the programme consists. If, however, he be admitted let him be destined for the artillery or for the engineers. The career of the sciences of which you have talked to me is really too difficult to go through, and, unless he had a special calling for it, your son would only find it deceptive." Anticipating a little the order of dates, let us compare this advice with what occurred. I went to Toulouse, underwent the examination, and was admitted. One year and a half afterward I filled the situation of secretary at the Observatory, which had become vacant by the resignation of M. Méchain's son. One year and a half later, that is to say, four years after the Perpignan "horoscope," associated with M. Biot, I filled the place, in Spain, of the celebrated academician who had died there, a victim to his labors.

case of the theory of osculations which I had studied in Lagrange's "Fonctions Analytiques." "Finally," said the examiner to me, "how do you determine the tension of the various cords of which a funicular machine is composed?" I treated this problem according to the method expounded in the "Mécanique Analytique." It was clear that Lagrange had supplied all the resources of my examination.

I had been two hours and a quarter at the board. M. Monge, going from one extreme to the other, got up, came and embraced me, and solemnly declared that I should occupy the first place on his list. Shall I confess it? During the examination of my comrade I had heard the Toulousian candidates uttering not very favorable sarcasms on the pupils from Perpignan; and it was principally for the sake of reparation to my native town that M. Monge's behavior and declaration transported me with joy.

Having entered the Polytechnic School, at the end of 1803 I was placed in the excessively boisterous brigade of the Gascons and Britons. I should have much liked to study thoroughly physics and chemistry, of which I did not even know the first rudiments; but the behavior of my companions rarely left me any time for it. As for analysis, I had, already, before entering the Polytechnic School, learned much more than was required for leaving it.

I have just related the strange words which M. Monge, jr., addressed to me at Toulouse in commencing my examination for admission. Something analogous occurred at the opening of my examination in mathematics for passing from one division of the school to another. The examiner, this time, was the illustrious geometer Legendre, of whom, a few years after, I had the honor of becoming the colleague and the friend.

I entered his study at the moment when M. T——, who was to undergo his examination before me, having fainted away, was being carried out in the arms of two servants. I thought that this circumstance would have moved and softened M. Legendre; but it had no such effect. "What is your name," he said to me sharply. "Arago," I answered. "You are not French, then?" "If I was not French I should not be before you; for I have never heard of any one being admitted into the school unless his nationality had been proved." "I maintain that he is not French whose name is Arago." "I maintain, on my side, that I am French, and a very good Frenchman, too, however strange my name may appear to you." "Very well; we will not discuss the point farther; go to the board."

I had scarcely taken up the chalk, when M. Legendre, returning to the first subject of his preoccupations, said to me: "You were born in one of the departments recently united to France?" "No, sir; I was born in the department of the Eastern Pyrenees, at the foot of the Pyrenees." "Oh! why did you not tell me that at once? All is now explained. You are of Spanish origin are you not?" "Possibly; but

in my humble family there are no authentic documents preserved which could enable me to trace back the civil position of my ancestors. Each one there is the child of his own deeds. I declare to you again that I am French, and that ought to be sufficient for you."

The vivacity of this last answer had not disposed M. Legendre in my favor. I saw this very soon; for, having put a question to me which required the use of double integrals, he stopped me, saying: "The method which you are following was not given to you by the professor. Whence did you get it?" "From one of your papers." "Why did you choose it? Was it to bribe me?" "No; nothing was farther from my thoughts. I only adopted it because it appeared to me preferable." "If you are unable to explain to me the reasons for your preference, I declare to you that you shall receive a bad mark, at least as to character."

I then entered upon the details which established, as I thought, that the method of double integrals was in all points more clear and more rational than that which Lacroix had expounded to us in the amphitheater. From this moment Legendre appeared to me to be satisfied, and to relent.

Afterward, he asked me to determine the center of gravity of a spherical sector. "The question is easy," I said to him. "Very well; since you find it easy, I will complicate it; instead of supposing the density constant, I will suppose that it varies from the center to the surface according to a determined function." I got through this calculation very happily; and from this moment I had entirely gained the favor of the examiner. Indeed, on my retiring, he addressed to me these words, which, coming from him, appeared to my comrades as a very favorable augury for my chance of promotion: "I see that you have employed your time well; go on in the same way the second year, and we shall part very good friends."

In the mode of examination adopted at the Polytechnic School in 1804, which is always cited as being better than the present organization, room was allowed for the exercise of some unjustifiable caprices. Would it be believed, for example, that the old M. Barruel examined two pupils at a time in physics, and gave them, it is said, the same mark, which was the mean between the actual merits of the two? For my part, I was associated with a comrade full of intelligence, but who had not studied this branch of the course. We agreed that he should leave the answering to me, and we found the arrangement advantageous to both.

As I have been led to speak of the school as it was in 1804, I will say that its faults were less those of organization than those of personal management; for many of the professors were much below their office, a fact which gave rise to somewhat ridiculous scenes. The pupils, for instance, having observed the insufficiency of M. Hassenfratz, made a demonstration of the dimensions of the rainbow, full of errors of calculation, but in which the one compensated the other so that the final

result was true. The professor, who had only this result whereby to judge of the goodness of the answer, when he saw it appear on the board, did not hesitate to call out, "Good, good, perfectly good!" which excited shouts of laughter on all the benches of the amphitheater.

When a professor has lost consideration, without which it is impossible for him to do well, they allow themselves to insult him to an incredible extent. Of this I will cite a single specimen.

A pupil, M. Leboullenger, met one evening in company this same M Hassenfratz, and had a discussion with him. When he reëntered the school in the morning, he mentioned this circumstance to us. "Be on your guard," said one of our comrades to him; "you will be interrogated this evening. Play with caution, for the professor has certainly prepared some great difficulties so as to cause laughter at your expense."

Our anticipations were not mistaken. Scarcely had the pupils arrived in the amphitheater, when M. Hassenfratz called to M. Leboullenger, who came to the board.

"M. Leboullenger," said the professor to him, "you have seen the moon?" "No, sir." "How, sir! you say that you have never seen the moon?" "I can only repeat my answer—no, sir." Beside himself, and seeing his prey escape him, by means of this unexpected answer, M. Hassenfratz addressed himself to the inspector charged with the observance of order that day, and said to him, "Sir, there is M. Leboullenger, who pretends never to have seen the moon." "What would you wish me to do?" stoically replied M. Le Brun. Repulsed on this side, the professor turned once more toward M. Leboullenger, who remained calm and earnest in the midst of the unspeakable amusement of the whole amphitheater, and cried out with undisguised anger, "You persist in maintaining that you have never seen the moon?" "Sir," returned the pupil, "I should deceive you if I told you that I had not heard it spoken of, but I have never seen it." "Sir, return to your place."

After this scene, M. Hassenfratz was but a professor in name; his teaching could not longer be of any use.

At the commencement of the second year I was appointed "*chef de brigade*." Hatchette had been professor of hydrography at Collioure; his friends from Roussillon recommended me to him. He received me with great kindness, and even gave me a room in his lodgings. It was there that I had the pleasure of making Poisson's acquaintance, who lived next to us. Every evening the great geometer entered my room, and we passed entire hours in conversing on politics and mathematics, which is certainly not quite the same thing.

In the course of 1804 the school was a prey to political passions, and that through the fault of the government.

They wished forthwith to oblige the pupils to sign an address of congratulation on the discovery of the conspiracy in which Moreau was implicated. They refused to do so on the ground that it was not for them to pronounce on a cause which had been in the hands of justice.

It must, however, be remarked, that Moreau had not yet dishonored himself by taking service in the Russian army, which had come to attack the French under the walls of Dresden.

The pupils were invited to make a manifestation in favor of the institution of the Legion of Honor. This again they refused. They knew well that the cross, given without inquiry and without control, would be, in most cases, the recompense of charlatanism, and not of true merit.

The transformation of the consular into the imperial government gave rise to very animated discussions in the interior of the school.

Many pupils refused to add their felicitations to the mean adulations of the constituted bodies.

General Lacuée, who was appointed governor of the school, reported this opposition to the Emperor.

"M. Lacuée," cried Napoleon, in the midst of a group of courtiers, who applauded with speech and gesture, "you cannot retain at the school those pupils who have shown such ardent republicanism; you will send them away." Then, collecting himself, he added, "I will first know their names and their stages of promotion." Seeing the list the next day, he did not proceed further than the first name, which was the first in the artillery. "I will not drive away the first men in advancement," said he. "Ah! if they had been at the bottom of the list! M. Lacuée, leave them alone."

Nothing was more curious than the *séance* to which General Lacuée came to receive the oath of obedience from the pupils. In the vast amphitheater which contained them, one could not discern a trace of the gravity which such a ceremony should inspire. The greater part, instead of answering, at the call of their names, "I swear it," cried out, "Present."

All at once, the monotony of this scene was interrupted by a pupil, son of the Conventionalist Brissot, who called out in a stentorian voice, "I will not take the oath of obedience to the Emperor." Lacuée, pale, and with little presence of mind, ordered a detachment of armed pupils placed behind him to go and arrest the recusant. The detachment, of which I was at the head, refused to obey. Brissot, addressing himself to the General, with the greatest calmness said to him, "Point out the place to which you wish me to go; do not force the pupils to dishonor themselves by laying hands on a comrade who has no desire to resist."

The next morning Brissot was expelled.

About this time, M. Méchain, who had been sent to Spain to prolong the meridional line as far as Formentera, died at Castellon de la Plana. His son, secretary at the observatory, immediately gave in his resignation. Poisson offered me the situation. I declined his first proposal. I did not wish to renounce the military career, the object of all my predilections, and in which, morever, I was assured of the protection of

Marshal Lannes, a friend of my father's. Nevertheless I accepted, on trial, the position offered me in the observatory, after a visit which I made to M. de Laplace in company with M. Poisson, under the express condition that I could reënter the artillery if that should suit me. It was from this cause that my name remained inscribed on the list of the pupils of the school. I was only detached to the observatory on a special service.

I entered this establishment, then, on the nomination of Poisson, *my* friend, and through the intervention of Laplace. The latter loaded me with civilities. I was happy and proud when I dined in the Rue de Tournon with the great geometer. My mind and my heart were much disposed to admire all, to respect all, that was connected with him who had discovered the cause of the secular equation of the moon, had found in the movement of this planet the means of calculating the ellipticity of the earth, had traced to the laws of attraction the long inequalities of Jupiter and of Saturn, &c., &c. But what was my disenchantment when one day I heard Madame de Laplace, approaching her husband, say to him, "Will you intrust to me the key of the sugar."

Some days afterward, a second incident affected me still more vividly. M. de Laplace's son was preparing for the examinations of the Polytechnic School. He came sometimes to see me at the observatory. In one of his visits I explained to him the method of continued fractions, by help of which Lagrange obtains the roots of numerical equations. The young man spoke of it to his father with admiration. I shall never forget the rage which followed the words of Emile de Laplace, and the severity of the reproaches which were addressed to me, for having patronized a mode of proceeding which may be very long in theory, but which evidently can in no way be found fault with on the score of its elegance and precision. Never had a jealous prejudice shown itself more openly, or under a more bitter form. "Ah!" said I to myself, "how true was the inspiration of the ancients when they attributed weaknesses to him who nevertheless made Olympus tremble by a frown."

Here I should mention, in order of time, a circumstance which might have produced the most fatal consequences for me. The fact was this:

I have described above, the scene which caused the expulsion of Brissot's son from the Polytechnic School. I had entirely lost sight of him for several months, when he came to pay me a visit at the observatory, and placed me in the most delicate, the most terrible position that an honest man ever found himself in.

"I have not seen you," he said to me, "because since leaving the school I have practiced daily firing with a pistol; I have now acquired a skill beyond the common, and I am about to employ it in ridding France of the tyrant who has confiscated all her liberties. My measures are taken; I have hired a small room on the Carrousel, close to the place by which Napoleon, on coming out from the court, will pass to

review the cavalry; from the humble window of my apartment will the ball be fired which will go through his head."

I leave it to be imagined with what despair I received this confidence. I made every imaginable effort to deter Brissot from his sinister project: I remarked how all those who had rushed on enterprises of this nature had been branded in history by the odious title of assassin. Nothing succeeded in shaking his fatal resolution; I only obtained from him a promise on his honor that the execution of it should be postponed for a time, and I put myself in quest of means for rendering it abortive.

The idea of announcing Brissot's project to the authorities did not even enter my thoughts. It seemed a fatality which came to smite me, and of which I must undergo the consequences, however serious they might be.

I counted much on the solicitations of Brissot's mother, already so cruelly tried during the revolution. I went to her home, in the Rue de Condé, and implored her earnestly to coöperate with me in preventing her son from carrying out his sanguinary resolution. "Ah, sir," replied this lady, who was naturally a model of gentleness, "if Silvain" (this was the name of her son) "believes that he is accomplishing a patriotic duty, I have neither the intention nor the desire to turn him from his project."

It was from myself that I must henceforth draw all my resources. I had remarked that Brissot was addicted to the composition of romances and pieces of poetry. I encouraged this passion, and every Sunday, above all, when I knew that there would be a review, I went to fetch him, and drew him into the country, in the environs of Paris. I listened then complacently to the reading of those chapters of his romance which he had composed during the week.

The first excursions frightened me a little, for, armed with his pistols, Brissot seized every occasion of showing his great skill; and I reflected that this circumstance would lead to my being considered as his accomplice, if he ever carried out his project. At last, his pretensions to literary fame, which I flattered to the utmost, the hopes (though I had none myself) which I led him to conceive of the success of an attachment of which he had confided the secret to me, made him receive with attention the reflections which I constantly made to him on his enterprise. He determined on making a journey beyond the seas, and thus relieved me from the most serious anxiety which I have experienced in all my life.

Brissot died after having covered the walls of Paris with printed handbills in favor of the Bourbon restoration.

I had scarcely entered the observatory, when I became the fellow-laborer of Biot in researches on the refraction of gases, already commenced by Borda.

While engaged in this work the celebrated academician and I often conversed on the interest there would be in resuming in Spain the

measurement interrupted by the death of Méchain. We submitted our project to Laplace, who received it with ardor, procured the necessary funds, and the government confided to us two this important mission.

M. Biot, I, and the Spanish commissary Rodriguez departed from Paris in the commencement of 1806. We visited, on our way, the stations indicated by Méchain, we made some important modifications in the projected triangulation, and at once commenced operations.

An inaccurate direction given to the reflectors established at Iviza, on the mountain Campvey, rendered the observations made on the continent extremely difficult. The light of the signal of Campvey was very rarely seen, and I was, during six months, in the *Desierto de las Palmas*, without being able to see it, while at a later period the light established at the Desierto, but well directed, was seen every evening from Campvey. It will easily be imagined what must be the *ennui* experienced by a young and active astronomer, confined to an elevated peak, having for his walk only a space of twenty square meters, and for diversion only the conversation of two Carthusians, whose convent was situated at the foot of the mountain, and who came in secret, infringing the rule of their order.

At the time when I write these lines, old and infirm, my legs scarcely able to sustain me, my thoughts revert involuntarily to that epoch of my life when, young and vigorous, I bore the greatest fatigues, and walked day and night, in the mountainous countries which separate the kingdoms of Valencia and Catalonia from the kingdom of Aragon, in order to reëstablish our geodesic signals which the storms had overset.

I was at Valencia toward the middle of October, 1806. One morning early the French consul entered my room quite alarmed: "Here is sad news," said M. Lanusse to me; "make preparations for your departure; the whole town is in agitation; a declaration of war against France has just been published; it appears that we have experienced a great disaster in Prussia. The Queen, we are assured, has put herself at the head of the cavalry and of the royal guard; a part of the French army has been cut to pieces; the rest is completely routed. Our lives would not be in safety if we remained here; the French ambassador at Madrid will inform me as soon as an American vessel now at anchor in the 'Grao' of Valencia can take us on board, and I will let you know as soon as the moment is come." This moment never came; for a few days afterward the false news, which one must suppose had dictated the proclamation of the Prince of the Peace, was replaced by the bulletin of the battle of Jéna. People who at first played the braggart and threatened to root us out suddenly became disgracefully cast down; we could walk in the town, holding up our heads, without fear henceforth of being insulted.

This proclamation, in which they spoke of the critical circumstances in which the Spanish nation was placed; of the difficulties which encompassed this people; of the safety of their native country; of laurels,

and of the god of victory; of enemies with whom they ought to fight—did not contain the name of France. They availed themselves of this omission (will it be believed?) to maintain that it was directed against Portugal.

Napoleon pretended to believe in this absurd interpretation; but from this moment it became evident that Spain would sooner or later be obliged to render a strict account of the warlike intentions which she had suddenly evinced in 1806; this, without justifying the events of Bayonne, explains them in a very natural way.

I was expecting M. Biot at Valencia, he having undertaken to bring some new instruments with which we were to measure the latitude of Formentera. I shall take advantage of these short intervals of repose to insert here some details of manners, which may, perhaps, be read with interest.

I will recount, in the first instance, an adventure which nearly cost me my life under somewhat singular circumstances:

One day, as a recreation, I thought I could go, with a fellow-countryman, to the fair at Murviedro, the ancient Saguntum, which they told me was very curious. I met in the town the daughter of a Frenchman resident at Valencia, Mdlle. B——. All the hotels were crowded; Mdlle. B—— invited us to take some refreshments at her grandmother's; we accepted; but on leaving the house she informed us that our visit had not been to the taste of her betrothed, and that we must be prepared for some sort of attack on his part; we went directly to an armorer's, bought some pistols, and commenced our return to Valencia.

On our way I said to the calezero, (driver,) a man whom I had employed for a long time, and who was much devoted to me:

"Isidro, I have some reason to believe that we shall be stopped; I warn you of it, so that you may not be surprised at the shots which will be fired from the caleza," (vehicle.)

Isidro, seated on the shaft, according to the custom of the country, answered:

"Your pistols are completely useless, gentlemen; leave me to act; one cry will be enough; my mule will rid us of two, three, or even four men."

Scarcely one minute had elapsed after the calezero had uttered these words, when two men presented themselves before the mule and seized her by the nostrils. At the same instant a formidable cry, which will never be effaced from my remembrance—the cry of *Capitana!*—was uttered by Isidro. The mule reared up almost vertically, raising up one of the men, came down again, and set off at a rapid gallop. The jolt which the carriage made led us to understand too well what had just occurred. A long silence succeeded this incident; it was only interrupted by these words of the calezero, "Do you not think, gentlemen, that my mule is worth more than any pistols?"

The next day the Captain General, Don Domingo Izquierdo, related

to me that a man had been found crushed on the road to Murviedro. I gave him an account of the prowess of Isidro's mule, and no more was said.

One anecdote, taken from among a thousand, will show what an adventurous life was led by the delegate of the Bureau of Longitude.

During my stay on a mountain near Cullera, to the north of the mouth of the river Xucar, and to the south of the Albuféra, I once conceived the project of establishing a station on the high mountains which are in front of it. I went to see them. The alcaid of one of the neighboring villages warned me of the danger to which I was about to expose myself. "These mountains," said he to me, "form the resort of a band of highway robbers." I asked for the national guard, as I had the power to do so. My escort was supposed by the robbers to be an expedition directed against them, and they dispersed themselves at once over the rich plain which is watered by the Xucar. On my return I found them engaged in combat with the authorities of Cullera. Wounds had been given on both sides, and, if I recollect right, one alguazil was left dead on the plain.

The next morning I regained my station. The following night was a horrible one; the rain fell in a deluge. Toward night there was knocking at my cabin door. To the question "Who is there?" the answer was, "A custom-house guard, who asks of you a shelter for some hours." My servant having opened the door to him, I saw a magnificent man enter, armed to the teeth. He laid himself down on the earth, and went to sleep. In the morning, as I was chatting with him at the door of my cabin, his eyes flashed on seeing two persons on the slope of the mountain, the alcaid of Cullera and his principal alguazil, who were coming to pay me a visit. "Sir," cried he, "nothing less than the gratitude which I owe to you, on account of the service which you have rendered to me this night, could prevent my seizing this occasion for ridding myself, by one shot of this carabine, of my most cruel enemy. Adieu, sir!" And he departed, springing from rock to rock as light as a gazelle.

On reaching the cabin, the alcaid and his alguazil recognized in the fugitive the chief of all the brigands in the country.

Some days afterward, the weather having again become very bad, I received a second visit from the pretended custom-house guard, who went soundly to sleep in my cabin. I saw that my servant, an old soldier, who had heard the recital of the deeds and behavior of this man, was preparing to kill him. I jumped down from my camp bed, and, seizing my servant by the throat, "Are you mad?" said I to him; "are we to discharge the duties of police in this country? Do you not see, moreover, that this would expose us to the resentment of all those who obey the orders of this redoubted chief? and we should thus render it impossible for us to terminate our operations."

Next morning, when the sun rose, I had a conversation with my guest, which I will try to reproduce faithfully.

"Your situation is perfectly known to me; I know that you are not a custom-house guard; I have learned from certain information that you are the chief of the robbers of the country. Tell me whether I have anything to fear from your confederates."

"The idea of robbing you did occur to us, but we concluded that all your funds would be in the neighboring towns; that you would carry no money to the summit of mountains, where you would not know what to do with it, and that our expedition against you could have no fruitful result. Moreover, we cannot pretend to be as strong as the King of Spain. The King's troops leave us quietly enough to exercise our industry, but on the day that we molested an envoy from the Emperor of the French, they would direct against us several regiments, and we should soon have to succumb. Allow me to add, that the gratitude which I owe to you is your surest guarantee."

"Very well, I will trust in your words; I shall regulate my conduct by your answer. Tell me if I can travel at night; it is fatiguing to me to move from one station to another in the day under the burning influence of the sun."

"You can do so, sir; I have already given my orders to this purpose; they will not be infringed."

Some days afterward I left for Denia; it was midnight, when some horsemen rode up to me, and addressed these words to me:

"Stop there, señor; times are hard; those who have something must aid those who have nothing. Give us the keys of your trunks; we will only take your superfluities."

I had already obeyed their orders, when it came into my head to call out, "But I have been told that I could travel without risk."

"What is your name, sir?"

"Don Francisco Arago."

"*Hombre! vaya usted con Dios,*" (God be with you.)

And our cavaliers, spurring away from us, rapidly lost themselves in a field of "algarrobas."

When *my friend* the robber of Cullera assured me that I had nothing to fear from his subordinates, he informed me at the same time that his authority did not extend north of Valencia. The banditti of the northern part of the kingdom obeyed other chiefs, one of whom, after having been taken, was condemned and hung, and his body divided into four quarters, which were fastened to posts on four royal roads, but not without their having previously been boiled in oil, to make sure of their longer preservation.

This barbarous custom produced no effect, for scarcely was one chief destroyed before another presented himself to replace him.

Of all these brigands those had the worst reputation who carried on their depredations in the environs of Oropeza. The proprietors of the three mules on which M. Rodriguez, I, and my servant were riding one evening in this neighborhood were recounting to us the "grand deeds"

of these robbers, which, even in full daylight, would have made the hair of one's head stand on end, when, by the faint light of the moon, we perceived a man hiding himself behind a tree. We were six, and yet this sentry on horseback had the audacity to demand our purses or our lives. My servant at once answered him, "You must then believe us to be very cowardly; take yourself off, or I will bring you down by one shot of my carabine." "I will be off," returned the worthless fellow, "but you will soon hear news of me." Still full of fright at the remembrance of the stories which they had just been relating, the three "arieros" besought us to quit the high road and cast ourselves into a wood which was on our left. We yielded to their proposal, but we lost our way. "Dismount," said they, "the mules have been obeying the bridle, and you have directed them wrongly. Let us retrace our way as far as the high road and leave the mules to themselves; they will well know how to find their right way again." Scarcely had we effected this maneuver, which succeeded marvellously well, when we heard a lively discussion taking place at a short distance from us. Some were saying, "We must follow the high road, and we shall meet with them." Others maintained that they must get into the wood on the left. The barking of the dogs, by which these individuals were accompanied, added to the tumult. During this time we pursued our way silently, more dead than alive. It was two o'clock in the morning. All at once we saw a faint light in a solitary house; it was like a light-house for the mariner in the midst of the tempest, and the only means of safety which remained to us. Arrived at the door of the farm, we knocked and asked for hospitality. The inmates, very little reassured, feared that we were thieves, and did not hurry themselves to open to us.

Impatient at the delay, I cried out, as I had received authority to do so, "In the name of the King, open to us." They obeyed an order thus given; we entered pell-mell, and in the greatest haste, men and mules into the kitchen, which was on the ground floor; and we hurried to extinguish the lights, in order not to awaken the suspicions of the bandits who were seeking for us. Indeed, we heard them, passing and repassing near the house, vociferating with the whole force of their lungs against their unlucky fate. We did not quit this solitary house until broad day, and we continued our route for Tortosa, not without having given a suitable recompense to our hosts. I wished to know by what providential circumstance they happened to have a lamp burning at that unseasonable hour. "We had killed a pig," they told me, "in the course of the day, and we were busy preparing the black puddings." Had the pig lived one day more, or had there been no black puddings, I should certainly have been no longer in this world, and I should not have the opportunity to relate the story of the robbers of Oropeza.

Never could I better appreciate the intelligent measure by which the constituent assembly abolished the ancient division of France into provinces, and substituted its division into departments, than in traversing

for my triangulation the Spanish border kingdoms of Catalonia, Valencia, and Aragon. The inhabitants of these three provinces detested each other cordially, and nothing less than the bond of a common hatred was necessary to make them act simultaneously against France. Such was their animosity in 1807 that I could scarcely make use at the same time of Catalonians, Aragons, and Valencians, when I moved with my instruments from one station to another. The Valencians in particular were treated by the Catalonians as a light, trifling, inconsistent people. They were in the habit of saying to me, "*En el reino de Valencia la carne es verdura, la verdura agua, los hombres mugeres, las mugeres nada,*" which may be translated thus: "In the kingdom of Valencia meat is a vegetable, vegetables are water, men are women, and women nothing."

On the other hand, the Valencians, speaking of the Aragons, used to call them "*schuros.*"

Having asked of a herdsman of this province who had brought some goats near to one of my stations what was the origin of this denomination, at which his compatriots showed themselves so offended:

"I do not know," said he, smiling cunningly at me, "whether I dare answer you." "Go on, go on," I said to him, "I can hear anything without being angry." "Well, the word *schuros* means that, to our great shame, we have sometimes been governed by French kings. The sovereign, before assuming power, was bound to promise under oath to respect our freedom, and to articulate in a loud voice the solemn words *lo Juro!* As he did not know how to pronounce the J, he said *schuro.* Are you satisfied, señor?" I answered him, "Yes, yes; I see that vanity and pride are not dead in this country."

Since I have just spoken of a shepherd, I will say that in Spain the class of individuals of both sexes destined to look after herds appeared to me always less further removed than in France from the pictures which the ancient poets have left us of the shepherds and shepherdesses in their pastoral poetry. The songs by which they endeavor to while away the tedium of their monotonous life are more remarkable in their form and substance than in the other European nations to which I have had access. I never recollect without surprise that, being on a mountain situated at the junction-point of the kingdoms of Valencia, Aragon, and Catalonia, I was all at once overtaken by a violent storm, which forced me to take refuge in my tent, and to remain there squatting on the ground. When the storm was over and I came out from my retreat, I heard, to my great astonishment, on an isolated peak which looked down upon my station, a shepherdess, who was singing a song, of which I only recollect these eight lines, which will give an idea of the rest:

* * * * *

A los que amor no saben
   Ofreces las dulzuras
Y a mi las amarguras
   Que s'e lo que es amar.

Las gracias al me certo
  Eran cuadro de flores
Te cantaban amorese
  Por hacerte callar.

Oh! how much sap there is in this Spanish nation! What a pity that they will not make it yield fruit?

In 1807, the tribunal of the Inquisition existed still at Valencia, and at times performed its functions. The reverend fathers, it is true, did not burn people, but they pronounced sentences in which the ridiculous contended with the odious. During my residence in this town, the holy office had to busy itself about a pretended sorceress; it doomed her to go through all quarters of the town astride on an ass, her face turned toward the tail, and naked down to the waist. Merely to observe the commonest rules of decency, the poor woman had been plastered with a sticky substance, partly honey, they told me, to which adhered an enormous quantity of little feathers, so that, to say the truth, the victim resembled a fowl with a human head. The procession, whether attended by a crowd I leave it to be imagined, stationed itself for some time in the cathedral square, where I lived. I was told that the sorceress was struck on the back a certain number of blows with a shovel; but I do not venture to affirm this, for I was absent at the moment when this hideous procession passed before my windows.

We thus see, however, what sort of spectacles were given to the people in the commencement of the nineteenth century, in one of the principal towns of Spain, the seat of a celebrated university, and the native country of numerous citizens distinguished by their knowledge, their courage, and their virtues. Let not the friends of humanity and of civilization disunite; let them form, on the contrary, an indissoluble union, for superstition is always on the watch, and waits for the moment again to seize its prey.

I have mentioned in the course of my narrative that two Carthusians often left their convent in the *Desierto de las Palmas*, and came though prohibited, to see me at my station, situated about two hundred meters higher. A few particulars will give an idea of what certain monks were, in the Peninsula, in 1807.

One of them, Father Trivulce, was old; the other was very young. The former, of French origin, had played a part at Marseilles, in the counter-revolutionary events of which this town was the theater, at the commencement of our first revolution. His part had been a very active one; one might see the proof of this in the scars of saber cuts which furrowed his breast. It was he who was the first to come. When he saw his young comrade march up, he hid himself; but as soon as the latter had fully entered into conversation with me, Father Trivulce showed himself all at once. His appearance had the effect of Medusa's head. "Reassure yourself," said he to his young compeer; "only let us not denounce each other, for our prior is not a man to pardon us for

having come here and infringed our vow of silence, and we should both receive a punishment, the recollection of which would long remain." The treaty was at once concluded, and from that day forward the two Carthusians came very often to converse with me.

The youngest of our two visitors was an Aragonian; his family had made him a monk against his will. He related to me one day, before M. Biot, (then returned from Tarragon, where he had taken refuge to get cured of his fever,) some particulars which, according to him, proved that in Spain there was no longer more than the ghost of religion. These details were mostly borrowed from the secrets of confession. M. Biot manifested sharply the displeasure which this conversation caused him; there were even in his language some words which led the monk to suppose that M. Biot took him for a kind of spy. As soon as this suspicion had entered his mind, he quitted us without saying a word, and the next morning I saw him come up early, armed with a light gun. The French monk had preceded him, and had whispered in my ear the danger that threatened my companion. "Join with me," he said, "to turn the young Aragonian monk from his murderous project." I need scarcely say that I employed myself with ardor in this negotiation, in which I had the happiness to succeed. There were here, as must be seen, the materials for a chief of *guerilleros*. I should be much astonished if my young monk did not play his part in the war of independence.

The anecdote which I am about to relate will amply prove that religion was, with the Carthusian monks of the *Desierto de las Palmas*, not the consequence of elevated sentiments, but a mere compound of superstitious practices.

The scene with the gun, always present to my mind, seemed to make it clear to me that the Aragon monk, if actuated by his passions, would be capable of the most criminal actions. Hence, I had a very disagreeable impression when one Sunday, having come down to hear mass, I met this monk, who, without saying a word, conducted me by a series of dark corridors into a chapel where the daylight penetrated only by a very small window. There I found Father Trivulce, who prepared himself to say mass for me alone. The young monk assisted. All at once, an instant before the consecration, Father Trivulce, turning toward me, said these exact words: "We have permission to say mass with white wine; we therefore make use of that which we gather from our own vines; this wine is very good. Ask the prior to let you taste it, when on leaving this you go to breakfast with him. For the rest, you can assure yourself this instant of the truth of what I say to you." And he presented me the goblet to drink from. I resisted strongly, not only because I considered it indecent to give this invitation in the middle of the mass, but because, besides, I must own I conceived the thought for a moment that the monks wished, by poisoning me, to reveng themselves on me for M. Biot having insulted them. I found that I was

mistaken, that my suspicions had no foundation; for Father Trivulce went on with the interrupted mass, drank, and drank largely, of the white wine contained in one of the goblets. But when I had got out of the hands of the two monks, and was able to breathe the pure air of the country, I experienced a lively satisfaction.

The right of asylum accorded to some churches was one of the most obnoxious privileges among those of which the revolution of 1798 rid France. In 1807, this right still existed in Spain, and belonged, I believe, to all the cathedrals. I learned, during my stay at Barcelona, that there was, in a little cloister contiguous to the largest church of the town, a brigand—a man guilty of several assassinations, who lived quietly there, guaranteed against all pursuit by the sanctity of the place. I wished to assure myself with my own eyes of the reality of the fact, and I went with my friend Rodriguez into the little cloister in question. The assassin was then eating a meal which a woman had just brought him. He easily guessed the object of our visit, and made immediately such demonstrations as convinced us that, if the asylum was safe for the robber, it would not be so long for us. We retired at once, deploring that in a country calling itself civilized there should still exist such crying, such monstrous abuses.

In order to succeed in our geodesic operations, to obtain the coöperation of the inhabitants of the villages near our stations, it was desirable for us to be recommended to the priests. We went, therefore—M. Lanusse, the French vice-consul, M. Biot, and I—to pay a visit to the Archbishop of Valencia, to solicit his protection. This archbishop, a man of very tall figure, was then chief of the Franciscans; his costume, more than negligent, his grey robe, covered with tobacco, contrasted with the magnificence of the archiepiscopal palace. He received us with kindness, and promised us all the recommendations we desired; but, at the moment of taking leave of him, the whole affair seemed to be spoiled. M. Lanusse and M. Biot went out of the reception-room without kissing the hand of his grace, although he had presented it to each of them very graciously. The archbishop indemnified himself on my poor person. A movement, which was very near breaking my teeth, a gesture which I might justly call a blow of the fist, proved to me that the chief of the Franciscans, notwithstanding his vow of humility, had taken offense at the want of ceremony in my fellow-visitors. I was going to complain of the abrupt way in which he had treated me, but I had the necessities of our trigonometrical operations before my eyes, and I was silent.

Besides this, at the instant when the closed fist of the archbishop was applied to my lips, I was still thinking of the beautiful optical experiments which it would have been possible to make with the magnificent stone which ornamented his pastoral ring. This idea, I must frankly declare, had preoccupied me during the whole of the visit.

M. Biot having at last come to seek me again at Valencia, where I ex-

pected, as I have before said, some new instruments, we went on to Formentera, the southern extremity of our arc, of which place we determined the latitude. M. Biot quitted me afterward to return to Paris, while I made the geodesical junction of the island of Majorca to Iviza, and to Formentera, obtaining thus, by means of one single triangle, the measure of an arc of parallel of one degree and a half.

I then went to Majorca, to measure there the latitude and the azimuth. At this epoch, the political fermentation, engendered by the entrance of the French into Spain, began to invade the whole Peninsula and the islands dependent on it. This ferment had as yet in Majorca only reached to the ministers, the partisans, and the relations of the Prince of Peace. Each evening I saw, drawn in triumph in the square of Palma, the capital of the island of Majorca, on carriages, the effigies in flames, sometimes of the minister Soller, another time those of the bishop, and even those of private individuals supposed to be attached to the fortunes of the favorite Godoï. I was far from suspecting then that my turn would soon arrive.

My station at Majorca, the *Clop de Galazo*, a very high mountain, was situated exactly over the port where *Don Jayme el Conquistator* disembarked when he went to deliver the Balearic Islands from the Moors. The report spread itself through the population that I had established myself there in order to favor the arrival of the French army, and that every evening I made signals to it. But these reports had nothing menacing until the moment of the arrival at Palma, the 27th of May, 1808, of an ordnance officer from Napoleon. This officer was M. Berthémie; he carried to the Spanish squadron, at Mahon, the order to go in all haste to Toulon. A general rising, which placed the life of this officer in danger, followed the news of his mission. The Captain General Vivés only saved his life by shutting him up in the strong castle of Belver. They then bethought themselves of the Frenchman established on the *Clop de Galazo*, and formed a popular expedition to go and seize him.

M. Damian, the owner of a small kind of vessel called a mistic, which the Spanish government had placed at my disposal, was beforehand with them, and brought me a costume by means of which I disguised myself. In directing myself toward Palma, in company with this brave seaman, we met with the rioters, who were going in search of me. They did not recognize me, for I spoke Majorcan perfectly. I strongly encouraged the men of this detachment to continue their route, and I pursued my way toward Palma. At night I went on board the mistic, commanded by Don Manuel de Vacaro, whom the Spanish government had placed under my orders. I asked this officer if he would conduct me to Barcelona, occupied by the French, promising him that, if they made any attempt to keep him there, I would at once return and surrender myself a prisoner.

Don Manuel, who up to this time had shown extreme obsequiousness

toward me, had now no words but those of rudeness and distrust. There occurred on the pier where the mistic was moored a riotous movement, which Vacaro assured me was directed against me. "Do not be uneasy," said he to me; "if they should penetrate into the vessel, you can hide yourself in this trunk." I made the attempt, but the chest which he showed me was so small that my legs were entirely outside, and the cover could not be shut down. I understood perfectly what that meant, and I asked M. Vacaro to let me also be shut up in the castle of Belver. The order for incarceration having arrived from the captain general, I got into the boat, where the sailors of the mistic received me with emotion.

At the moment of their crossing the harbor, the populace perceived me, commenced a pursuit, and it was not without much difficulty that I reached Belver safe and sound. I had only, indeed, received on my way one slight wound from a dagger in the thigh. Prisoners have often been seen to run with all speed *from* their dungeon; I am the first, perhaps, to whom it has happened to do the reverse. This took place on the 1st or 2d of June, 1808.

The governor of Belver was a very extraordinary personage; if he is still alive, he may demand of me a certificate as to his priority to the modern hydropathists. The grenadier captain maintained that pure water, suitably administered, was a means of treatment for all illnesses, even for amputations; by listening very patiently to his theories, and never interrupting him, I won his good opinion. It was at his request, and from interest in our safety, that a Swiss garrison replaced the Spanish troop which, until then, had been employed as the guard of Belver. It was also through him that I one day learned that a monk had proposed to the soldiers who went to bring my food from the town, to put some poison into one of the dishes.

All my old Majorcan friends had abandoned me at the moment of my detention. I had had a very sharp correspondence with Don Manuel de Vacaro, in order to obtain the restitution of the passport of safety which the English admiralty had granted to us. M. Rodriguez alone ventured to visit me in full daylight, and bring me every consolation in his power.

The excellent M. Rodriguez, to while away the monotony of my incarceration, remitted to me, from time to time, the journals which were then published at different parts of the Peninsula. He often sent them to me without reading them. Once I saw in these journals the recital of the horrible massacres of which the town of Valencia—I make a mistake, the *square of the bull-fights*—had been the theater, and in which nearly the whole of the French established in this town (more than three hundred and fifty) had disappeared under the pike of the bull-fighter. Another journal contained an article bearing this title, "Relacion de la ahorcadura del Señor Arago e del Señor Berthémie"—literally, "Account of the Execution of M. Arago and M. Berthémie."

This account spoke of the two executed men in very different terms. M. Berthémie was a Huguenot; he had been deaf to all exhortations; he had spit in the face of the ecclesiastic who was present, and even on the image of Christ. As for me, I had conducted myself with much decency, and had allowed myself to be hung without giving rise to any scandal. The writer also expressed his regret that a young astronomer had been so weak as to associate himself with treason, coming under the disguise of science to assist the entrance of the French army into a friendly kingdom.

After reading this article, I immediately made my decision. "Since they talk of my death," said I to my friend Rodriguez, "the event will not be long in coming; I should prefer being drowned to being hung. I will make my escape from this fortress; it is for you to furnish me with the means."

Rodriguez, knowing better than any one how well founded my apprehensions were, set himself at once to the work. He went to the captain general, and made him feel what would be the danger of his position if I should disappear in a popular riot, or even if he were forced to give me up. His observations were so much the better comprehended, as no one could then predict what might be the issue of the Spanish revolution. "I will undertake," said the captain general Vivés to my colleague Rodriguez, "to give an order to the commander of the fortress, that when the right moment arrives, he shall allow M. Arago, and even the two or three other Frenchmen who are with him in the castle of Belver, to pass out; they will then have no need of the means of escape which they have procured. But I will take no part in the preparations which will become necessary to enable the fugitives to leave the island; I leave all that to your responsibility."

Rodriguez immediately conferred secretly with the brave commander Damian. It was agreed between them that Damian should take the command of a half-decked boat which the wind had driven ashore; that he should equip it as if for a fishing expedition; that he should carry us to Algiers, after which his reëntrance at Palmas, with or without fish, would inspire no suspicion. All was executed according to agreement, notwithstanding the inquisitorial surveillance which Don Manuel de Vacaro exercised over the commander of his "mistic."

On the 28th July, 1808, we silently descended the hill on which Belver is built, at the same moment that the family of the minister Soller entered the fortress to escape the fury of the populace. Arrived at the shore, we found there Damian, his boat, and three sailors; we embarked at once, and set sail. Damian had taken the precaution of bringing with us in this frail vessel the instruments of value which he had carried off from my station at the *Clop de Galazo*. The sea was unfavorable; Damian thought it prudent to stop at the little island of Cabrera, destined to become, a short time afterward, so sadly celebrated by the sufferings which the soldiers of the army of Dupont experienced after

the shameful capitulation of Baylen. There a singular incident was very near compromising all: Cabrera, tolerably near to the southern extremity of Majorca, is often visited by fishermen coming from that part of the island. M. Berthémie feared, justly enough, that, the rumor of our escape having spread about, they might dispatch some boats to seize us. He looked upon our going into harbor as inopportune; I maintained that we must yield to the prudence of the commander. During this discussion, the three seamen whom Damian had engaged saw that M. Berthémie, whom I had endeavored to pass off as my servant, maintained his opinion against me on a footing of equality. They then addressed themselves in these terms to the commander:

"We only consented to take part in this expedition upon condition that the Emperor's aid-de-camp, shut up at Belver, should not be of the number of those persons whom we should help off; we only wished to aid the flight of the astronomer. Since it seems to be otherwise, you must leave this officer here, unless you would prefer to throw him into the sea."

Damian at once informed me of the imperative wishes of his boat's crew. M. Berthémie agreed with me to suffer some abuse, such as could only be tolerated by a servant threatened by his master: all the suspicions disappeared.

Damian, who feared also for himself the arrival of Majorcan fishermen, hastened to set sail on the 29th of July, 1808, the first moment that was favorable, and we arrived at Algiers on the 3d of August.

Our looks were anxiously directed toward the port, to guess what reception might await us. We were reassured by the sight of the tri-colored flag which was flying on two or three buildings; but we were mistaken, these buildings were Dutch. Immediately upon our entrance, a Spaniard, whom, from his tone of authority, we took for a high functionary of the regency, came up to Damian, and asked him, "What do you bring?" "I bring," answered the commander, "four Frenchmen." "You will at once take them back again; I prohibit you from disembarking." As we did not seem inclined to obey his order, our Spaniard, who was the constructing engineer of the ships of the Dey, armed himself with a pole, and commenced battering us with blows; but immediately a Genoese seaman, mounted on a neighboring vessel, armed himself with an oar, and struck our assailant both with edge and point. During this animated combat, we managed to land without any opposition. We had conceived a singular idea of the manner in which the police act on the coast of Africa.

We pursued our way to the French consul's, M. Dubois Thainville; he was at his country house. Escorted by the janissary of the consulate, we went off toward this country house, one of the ancient residences of the Dey, situated not far from the gate of Bab-azoum. The consul and his family received us with great amity, and offered us hospitality.

Suddenly transported to a new continent, I looked forward anxiously

to the rising of the sun to enjoy all that Africa might offer of interest to a European, when all at once I believed myself to be engaged in a serious adventure. By the faint light of the dawn, I saw an animal moving at the foot of my bed. I gave a kick with my foot; all movement ceased. After some time, I felt the same movement under my legs. A sharp jerk made this cease quickly. I then heard the fits of laughter of the janissary, who lay on a couch in the same room as I did; and I soon saw that he had simply placed on my bed a large hedgehog to amuse himself by my uneasiness.

The consul occupied himself the next day in procuring a passage for us on board a vessel of the Regency which was going to Marseilles. M. Ferrier, the chancellor of the French consulate, was at the same time consul for Austria. He procured for us two false passports, which transformed us—M. Berthémie and me—into two strolling merchants, the one from Schwekat, in Hungary, the other from Leoben.

The moment of departure had arrived; the 13th of August, 1808, we were on board, but our ship's company was not complete. The captain, whose title was Raï Braham Ouled Mustapha Goja, having perceived that the Dey was on his terrace, and fearing punishment if he should delay to set sail, completed his crew at the expense of the idlers who were looking on from the pier, and of whom the greater part were not sailors. These poor people begged as a favor for permission to go and inform their families of this precipitate departure, and to get some clothes. The captain remained deaf to their remonstrances. We weighed anchor.

The vessel belonged to the Emir of Seca, director of the mint. The real commander was a Greek captain, named Spiro Calligero. The cargo consisted of a great number of *groups*. Among the passengers there were five members of the family which the Bakri had succeeded as kings of the Jews; two ostrich-feather merchants, Moroccans; Captain Krog, from Berghen in Norway, who had sold his ship at Alicant; two lions sent by the Dey to the Emperor Napoleon, and a great number of monkeys. Our voyage was prosperous. Off Sardinia we met with an American ship coming out from Cagliari. A cannon-shot (we were armed with forty pieces of small power) warned the captain to come to be recognized. He brought on board a certain number of counterparts of passports, one of which agreed perfectly with that which we carried. The captain being thus all right, was not a little astonished when I ordered him, in the name of Captain Braham, to furnish us with tea, coffee, and sugar. The American captain protested; he called us brigands, pirates, robbers. Captain Braham admitted without difficulty all these qualifications, and persisted none the less in the exaction of sugar, coffee, and tea.

The American, then driven to the last stage of exasperation, addressed himself to me, who acted as interpreter, and cried out, "Oh! rogue of a renegade! if ever I meet you on holy ground I will break your head." "Can you then suppose," I answered him, "that I am here for my

pleasure, and that, nothwithstanding your menace, I would not rather go with you, if I could?" These words calmed him; he brought the sugar, the coffee, and the tea claimed by the Moorish chief and we again set sail, though without having exchanged the usual farewell.

We had already entered the Gulf of Lyons, and were approaching Marseilles, when on the 16th August, 1808, we met with a Spanish corsair from Palamos, armed at the prow with two 24-pounders. We made full sail; we hoped to escape it: but a cannon shot, a ball from which went through our sails, taught us that she was a much better sailer than we were.

We obeyed an injunction thus expressed, and awaited the great boat from the corsair. The captain declared that he made us prisoners, although Spain was at peace with Barbary, under the pretext that we were violating the blockade which had been lately raised on all the coasts of France; he added that he intended to take us to Rosas, and that there the authorities would decide on our fate.

I was in the cabin of the vessel; I had the curiosity to look furtively at the crew of the boat, and there I perceived, with a dissatisfaction which may easily be imagined, one of the sailors of the "mistic," commanded by Don Manuel de Vacaro, of the name of Pablo Blanco, of Palamos, who had often acted as my servant during my geodesec operations. My false passport would become from this moment useless, if Pablo should recognize me. I went to bed at once, covered my head with a counterpane, and lay as still as a statue.

During the two days which elapsed between our capture and our entrance into the roads of Rosas, Pablo, whose curiosity often brought him into the room, used to exclaim, "There is one passenger whom I have not yet managed to get a sight of."

When we arrived at Rosas it was decided that we should be placed in quarantine in a dismantled windmill, situated on the road leading to Figueras. I was careful to disembark in a boat to which Pablo did not belong. The corsair departed for a new cruise, and I was for a moment freed from the harassing thoughts which my old servant had caused me.

Our ship was richly laden; the Spanish authorities were immediately desirous to declare it a lawful prize. They pretended to believe that I was the proprietor of it, and wished, in order to hasten things, to interrogate me, even without awaiting the completion of the quarantine. They stretched two cords between the mill and the shore; and a judge placed himself in front of me. As the interrogatories were made from a good distance, the numerous audience which encircled us took a direct part in the questions and answers. I will endeavor to reproduce this dialogue with all possible fidelity:

"Who are you?"

"A poor roving merchant."

"Whence do you come?"

"From a country where you certainly never were."

"In a word, what country is it?"

I was afraid to answer, for the passports, steeped in vinegar, were in the hands of the judge-instructor, and I had forgotten whether I was from Schwekat or from Leoben. Finally I answered at all hazards:

"I come from Schwekat."

And this information happily was found to agree with that of the passport.

"You are as much from Schwekat as I am," answered the judge. "You are Spanish, and, moreover, a Spaniard from the kingdom of Valencia, as I perceive by your accent."

"Would you punish me, sir, because nature has endowed me with the gift of languages? I learn with facility the dialects of those countries through which I pass in the exercise of my trade; I have learned, for example, the dialect of Iviza."

"Very well, you shall be taken at your word. I see here a soldier from Iviza; you shall hold a conversation with him."

"I consent; I will even sing the goat song."

Each of the verses of this song (if verses they be) terminates by an imitation of the bleating of the goat.

I commenced at once, with an audacity at which I really feel astonished, to chant this air, which is sung by all the shepherds of the island:

Ah graciada señora
Una canzo bouil canta
Bè, bè, bè, bè.
No sera gaira pulida
Nosé si vos agradara
Bè, bè, bè, bè.

At once my Ivizacan, upon whom this air had the effect of the *ranz des vaches* on the Swiss, declared, all in tears, that I was a native of Iviza.

I then said to the judge that if he would put me in communication with a person knowing the French language, he would arrive at just as embarrassing a result. An *émigré* officer of the Bourbon regiment offered at once to make the experiment, and, after some phrases interchanged between us, affirmed without hesitation that I was French.

The judge, rendered impatient, exclaimed, "Let us put an end to these trials which decide nothing. I summon you, sir, to tell me who you are. I promise that your life will be safe if you answer me with sincerity."

"My greatest wish would be to give an answer to your satisfaction. I will, then, try to do so; but I warn you that I am not going to tell you the truth. I am the son of the innkeeper at Mataró." "I know that innkeeper; you are not his son." "You are right. I announced to you that I should vary my answers until one of them should suit you. I retract then, and tell you that I am a *titiretero* (player of marionettes) and that I practiced at Lerida."

A loud shout of laughter from the multitude encircling us greeted this answer, and put an end to the questions.

"I swear by the d——l," exclaimed the judge, "that I will discover sooner or later who you are!"

And he retired.

The Arabs, the Moroccans, the Jews, who witnessed this interrogatory, understood nothing of it; they had only seen that I had not allowed myself to be intimidated. At the close of the interview they came to kiss my hand, and gave me, from this moment, their entire confidence.

I became their secretary for all the individual or collective remonstrances which they thought they had a right to address to the Spanish government; and this right was incontestable. Every day I was occupied in drawing up petitions, especially in the name of the two ostrich-feather merchants, one of whom called himself a tolerably near relation of the Emperor of Morocco. Astonished at the rapidity with which I filled a page of my writing, they imagined, doubtless, that I should write as fast in Arabic characters, when it should be requisite to transcribe passages from the Koran; and that this would form both for me and for them the source of a brilliant fortune, and they besought me, in the most earnest way, to become a Mahomedan.

Very little reassured by the last words of the judge, I sought means of safety from another quarter.

I was the possessor of a safe-conduct from the English admiralty; I therefore wrote a confidential letter to the captain of an English vessel, the "Eagle," I think, which had cast anchor some days before in the roads at Rosas. I explained to him my position. "You can," I said, "claim me, because I have an English passport. If this proceeding should cost you too much, have the goodness at least to take my manuscripts and to send them to the Royal Society in London."

One of the soldiers who guarded us, and in whom I had fortunately inspired some interest, undertook to deliver my letter. The English captain came to see me; his name was, if my memory is right, George Eyre. We had a private conversation on the shore. George Eyre thought perhaps that the manuscripts of my observations were contained in a register bound in morocco, and with gilt edges to the leaves. When he saw that these manuscripts were composed of single leaves covered with figures, which I had hidden under my shirt, disdain succeeded to interest, and he quitted me hastily. Having returned on board he wrote me a letter which I could find if needful, in which he said to me, "I cannot mix myself up in your affairs; address yourself to the Spanish government; I am persuaded that it will do justice to your remonstrance and will not molest you." As I had not the same persuasion as Captain George Eyre, I chose to take no notice of his advice.

I ought to mention that some time after having related these particulars in England at Sir Joseph Banks's, the conduct of George Eyre was

severely blamed; but when a man breakfasts and dines to the sound of harmonious music, can he accord his interest to a poor devil sleeping on straw and nibbled by vermin, even though he have manuscripts under his shirt? I may add that I (unfortunately for me) had to do with a captain of an unusual character. For, some days later, a new vessel, the Colossus, having arrived in the roads, the Norwegian, Captain Krog, although he had not, like me, an admiralty passport, made an application to the commander of this new ship; he was immediately claimed and relieved from captivity.

The report that I was a Spanish deserter and proprietor of the vessel, acquiring more and more credit, and this position being the most dangerous of all, I resolved to get out of it. I begged the commandant of the place, M. Alloy, to come to receive my declaration, and I announced to him that I was French. To prove to him the truth of my words I invited him to send for Pablo Blanco, the sailor in the service of the corsair who took us, and who had returned from his cruise a short time before. This was done as I wished. In disembarking, Pablo Blanco, who had not been warned, exclaimed with surprise, "What! you Don Francisco, mixed up with all these miscreants!" The sailor gave the governor circumstantial evidence as to the mission which I fulfilled with two Spanish commissaries. My nationality thus became proved.

That same day Alloy was replaced in the command of the fortress by the Irish colonel of the Ultonian regiment; the corsair left for a fresh cruise, taking away Pablo Blanco; and I became once more the roving merchant from Schwekat.

From the windmill where we underwent our quarantine, I could see the tricolored flag flying on the fortress of Figueras. The reconnoitering parties of the cavalry came sometimes within five or six hundred meters; it would not then have been difficult for me to escape. However, as the regulations against those who violate the sanitary laws are very rigorous in Spain, as they pronounce the penalty of death against him who infringes them, I only determined to make my escape on the eve of our admission to pratique.

The night being come I crept on all-fours along the briars, and I should soon have got beyond the line of sentinels who guarded us. A noisy uproar which I heard among the Moors made me determine to reënter, and I found these poor people in an unspeakable state of uneasiness, thinking themselves lost if I left; I therefore remained.

The next day a strong picket of troops presented itself before the mill. The maneuvers made by it inspired all of us with anxiety, but especially Captain Krog.* "What will they do with us?" he exclaimed. "Alas! you will see only too soon," replied the Spanish officer. This answer made every one believe that they were going to shoot us. What might have strengthened me in this idea was the obstinacy with which

* This appears to be an oversight, as in a preceding page M. Arago described the fortunate release of Captain Krog from this captivity.

Captain Krog and two other individuals of small size hid themselves behind me. A handling of arms made us think that we had but a few seconds to live.

In analyzing the feelings which I experienced on this solemn occasion, I have come to the conclusion that the man who is led to death is not as unhappy as the public imagines him to be. Fifty ideas presented themselves nearly simultaneously to my mind, and I did not rack my brain for any of them; I only recollect the two following which have remained engraved on my memory. On turning my head to the right, I saw the national flag flying on the bastions of Figueras, and I said to myself, 'If I were to move a few hundred meters I should be surrounded by comrades, by friends, by fellow-citizens, who would receive me affectionately. Here, without their being able to impute any crime to me, I am going to suffer death at twenty-two years of age." But what agitated me more deeply was this: looking toward the Pyrenees I could distinctly see their peaks, and I reflected that my mother, on the other side of the chain, might at this awful moment be looking peaceably at them.

The Spanish authorities, finding that to redeem my life I would not declare myself the owner of the vessel, had us conducted without further molestation to the fortress of Rosas. Having to file through nearly all the inhabitants of the town, I had wished at first, through a false feeling of shame, to leave in the mill the remains of our week's meals. But M. Berthémie, more prudent than I, carried over his shoulder a great quantity of pieces of black bread tied up with packthread. I imitated him. I furnished myself famously from our old stock, set it on my shoulder, and it was with this accoutrement that I made my entrance into the famous fortress.

They placed us in a casemate, where we had barely the space necessary for lying down. In the windmill they used to bring us, from time to time, some provisions which came from our boat. Here, the Spanish government purveyed our food. We received every day some bread and a ration of rice; but as we had no means of dressing food, we were in reality reduced to dry bread.

Dry bread was very unsubstantial food for one who could see from his casemate, at the door of his prison, a sutler selling grapes at two farthings a pound, and cooking, under the shelter of half a cask, bacon and herrings; but we had no money to bring us into connection with this merchant. I then decided, though with very great regret, to sell a watch which my father had given me. I was only offered about a quarter of its value; but I might well accept it since there were no competitors for it.

As possessors of sixty francs, M. Berthémie and I could now appease the hunger from which we had long suffered; but we did not like this return of fortune to be profitable to ourselves alone, and we made some presents, which were very well received by our companions in captivity.

Though this sale of my watch brought some comfort to us, it was doomed at a later period to plunge a family into sorrow.

The town of Rosas fell into the power of the French after a courageous resistance. The prisoners of the garrison were sent to France, and naturally passed through Perpignan. My father went in quest of news wherever Spaniards were to be found. He entered a café at the moment when a prisoner officer drew from his fob the watch which I had sold at Rosas. My good father saw in this act the proof of my death, and fell into a swoon. The officer had got the watch from a third party, and could give no account of the fate of the person to whom it had originally belonged.

The casemate having become necessary to the defenders of the fortress, we were taken to a little chapel where they deposited for twenty-four hours those who had died in the hospital. There we were guarded by peasants who had come across the mountain from various villages, and particularly from Cadaquès. These peasants, eager to recount all that they had seen of interest during their one day's campaign, questioned me as to the deeds and behavior of all my companions in misfortune. I satisfied their curiosity amply, being the only one of the set who could speak Spanish.

To enlist their good will, I also questioned them at length upon the subject of their village, on the work that they did there, on smuggling, their principal sources of employment, &c., &c. They answered my questions with the loquacity common to country rustics. The next day our guards were replaced by some others who were inhabitants of the same village. "In my business of a roving merchant," I said to these last, "I have been at Cadaquès;" and then I began to talk to them of what I had learnt the night before of such an individual, who gave himself up to smuggling with more success than others, of his beautiful residence, of the property which he possessed near the village; in short, of a number of particulars which it seemed impossible for any but an inhabitant of Cadaquès to know. My jest produced an unexpected effect. Such circumstantial details, our guards said to themselves, cannot be known by a roving merchant; this personage whom we have found here in such singular society, is certainly a native of Cadaquès; and the son of the apothecary must be about his age. He had gone to try his fortune in America; it is evidently he, who fears to make himself known, having been found with all his riches in a vessel on its way to France. The report spread, became more consistent, and reached the ears of a sister of the apothecary established at Rosas. She runs to me, believes she recognizes me, and falls on my neck. I protest against the identity. "Well played!" said she to me; "the case is serious, as you have been found in a vessel coming to France; persist in your denial; circumstances may perhaps take a more favorable turn, and I shall profit by them to insure your deliverance. In the mean time, my

dear nephew, I will let you want for nothing." And truly every morning M. Berthémie and I received a comfortable repast.

The church having become necessary to the garrison to serve as a magazine, we were moved on the 25th of September, 1808, to a Trinity fort, called the *Bouton de Rosas*, a citadel situated on a little mountain at the entrance of the roads, and we were deposited deep under ground, where the light of day did not penetrate on any side. We did not long remain in this infected place; not because they had pity upon us, but because it offered shelter for a part of the garrison attacked by the French. They made us descend by night to the edge of the sea, and then transported us on the 17th of October to the port of Palamos. We were shut up in a hulk; we enjoyed, however, a certain degree of liberty; they allowed us to go on land and to parade our miseries and our rags in the town. It was there that I made the acquaintance of the dowager Duchess of Orleans, mother of Louis Phillippe. She had left the town of Figueras where she resided, because, she told me, thirty-two bombs sent from the fortress had fallen in her house. She was then intending to take refuge in Algiers, and she asked me to bring the captain of the vessel to her, of whom, perhaps, she would have to implore protection. I related to my "*raïs*" the misfortunes of the princess; he was moved by them, and I conducted him to her. On entering he took off his slippers from respect, as if he had entered within a mosque, and holding them in his hand, he went to kiss the front of the dress of Madame d'Orleans. The princess was alarmed at the sight of this manly figure, wearing the longest beard I ever saw; she quickly recovered herself, and the interview proceeded with a mixture of French politeness and oriental courtesy.

The sixty francs from Rosas were expended. Madame d'Orleans would have liked much to assist us, but she was herself without money. All that she could gratify us with was a piece of sugar-bread. The evening of our visit I was richer than the princess. To avoid the fury of the people the Spanish government sent those French who had escaped the first massacres back to France in slight boats. One of the *cartels* came and cast anchor by the side of our hulk. One of the unhappy emigrants offered me a pinch of snuff. On opening the snuff-box I found there "*una onza de oro*," (an ounce of gold,) the sole remains of his fortune. I returned the snuff-box to him, with warm thanks, after having shut up in it a paper containing these words: "My fellow-countryman who carries this note has rendered me a great service; treat him as one of your children." My petition was naturally favorably received; it was by this bit of paper, the size of the *onza de oro*, that my family learnt that I was still in existence, and it enabled my mother, a model of piety, to cease saying masses for the repose of my soul.

Five days afterward, one of my hardy compatriots arrived at Palamos, after having traversed the line of posts, both French and Spanish, carrying to a merchant who had friends at Perpignan the proposal to

furnish me with all I was in need of. The Spaniard showed a great inclination to agree to the proposal; but I did not profit by his good will, because of the occurrence of events which I shall relate presently.

The observatory at Paris is very near the barrier. In my youth, curious to study the manners of the people, I used to walk in sight of the public houses, which the desire of escaping payment of the duty has multiplied outside the walls of the capital. On these excursions I was often humiliated to see men disputing for a piece of bread, just as animals might have done. My feelings on this subject have very much altered since I have been personally exposed to the tortures of hunger. I have discovered, in fact, that a man, whatever may have been his origin, his education, and his habits, is governed, under certain circumstances, much more by his stomach than by his intelligence and his heart. Here is the fact which suggested these reflections to me:

To celebrate the unhoped-for arrival of *una onza de oro*, M. Berthémie and I had produced an immense dish of potatoes. The ordnance officer of the Emperor was already devouring it with his eyes, when a Moroccan, who was making his ablutions near us with one of his companions, accidentally filled it with dirt. M. Berthémie could not control his anger, he darted upon the clumsy Mussulman, and inflicted upon him a rough punishment.

I remained a passive spectator of the combat, until the second Moroccan came to the aid of his compatriot. The party no longer being equal, I also took part in the conflict, by seizing the new assailant by the beard. The combat ceased at once, because the Moroccan would not raise his hand against a man who could write a petition so rapidly. This conflict, like the struggles of which I had often been a witness outside the barriers of Paris, had originated in a dish of potatoes.

The Spaniards always cherished the idea that the ship and her cargo might be confiscated; a commission came from Girone to question us. It was composed of two civil judges and one inquisitor. I acted as interpreter. When M. Berthémie's turn came, I went to fetch him, and said to him, "Pretend that you can only talk Styrian, and be at ease; I will not compromise you in translating your answers."

It was done as we had agreed; unfortunately the language spoken by M. Berthémie had but little variety, and the *sacrement der Teufel*, which he had learned in Germany, when he was aide-de-camp to Hautpoul, predominated too much in his discourse. Be that as it may, the judges observed that there was too great a conformity between his answers and those which I had made myself to render it necessary to continue an interrogatory, which I may say, by the way, disturbed me much. The wish to terminate it was still more decided on the part of the judges, when it came to the turn of a sailor named Mehemet. Instead of making him swear on the Koran to tell the truth, the judge was determined to make him place his thumb on the fore-finger so as to represent the cross. I warned him that great offense would thus be given; and, accordingly,

when Mehemet became aware of the meaning of this sign, he began to spit upon it with inconceivable violence. The meeting ended at once.

The next day things had wholly changed their appearance; one of the judges from Girone came to declare to us that we were free to depart, and to go with our ship wherever we chose. What was the cause of this sudden change? It was this:

During our quarantine in the windmill at Rosas, I had written, in the name of Captain Braham, a letter to the Dey of Algiers. I gave him an account of the illegal arrest of his vessel, and of the death of one of the lions which the Dey had sent to the Emperor. This last circumstance transported the African monarch with rage. He sent immediately for the Spanish consul, M. Onis, claimed pecuniary damages for his dear lion, and threatened war if his ship was not released directly. Spain had then to do with too many difficulties to undertake wantonly any new ones, and the order to release the vessel so anxiously coveted arrived at Girone, and from thence at Palamos.

This solution, to which our consul at Algiers, M. Dubois Thainville, had not remained inattentive, reached us at the moment when we least expected it. We at once made preparations for our departure, and on the 28th of November, 1808, we set sail, steering for Marseilles; but, as the Mussulmen on board the vessel declared, it was written above that we should not enter that town. We could already perceive the white buildings which crown the neighboring hills of Marseilles, when a gust of the "mistral," of great violence, sent us from the north towards the south.

I do not know what route we followed, for I was lying in my cabin, overcome with sea-sickness; I may, therefore, though an astronomer, avow without shame, that at the moment when our unqualified pilots supposed themselves to be off the Baléares, we landed, on the 5th of December, at Bougie.

There, they pretended that during the three months of winter all communication with Algiers, by means of the little boats named *sandalis*, would be impossible, and I resigned myself to the painful prospect of so long a stay in a place at that time almost a desert. One evening I was making these sad reflections while pacing the deck of the vessel, when a shot from a gun on the coast came and struck the side planks close to which I was passing. This suggested to me the thought of going to Algiers by land.

I went next day, accompanied by M. Berthémie and Captain Spiro Calligero, to the Caïd of the town: "I wish," said I to him, "to go to Algiers by land." The man, quite frightened, exclaimed, "I cannot allow you to do so; you would certainly be killed on the road; your consul would make a complaint to the Dey, and I should have my head cut off."

"Fear not on that ground. I will give you an acquittance."

It was immediately drawn up in these terms:

"We, the undersigned, certify that the Caïd of Bougie wished to dissuade us from going to Algiers by land; that he has assured us that we shall be massacred on the road; that notwithstanding his representations, reiterated twenty times, we have persisted in our project. We beg the Algerine authorities, particularly our consul, not to make him responsible for this event if it should occur. We once more repeat that the voyage has been undertaken against his will.

"ARAGO AND BERTHÉMIE."

Having given this declaration to the Caïd, we considered ourselves quit of this functionary; but he came up to me, undid, without saying a word, the knot of my cravat, took it off, and put it into his pocket. All this was done so quickly that I had not time, I will add that I had not even the wish, to reclaim it.

At the conclusion of this audience, which had terminated in so singular a manner, we made a bargain with a Mahomedan priest, who promised to conduct us to Algiers for the sum of twenty "piastres fortes" and a red mantle. The day was occupied in disguising ourselves, well or ill, and we set out the next morning, accompanied by several Moorish sailors belonging to the crew of the ship, after having shown the Mahomedan priest that we had nothing with us worth a sou, so that if we were killed on the road he would inevitably lose all reward.

I went, at the last moment, to make my bow to the only lion that was still alive, and with whom I had lived in very good harmony; I wished also to say good-bye to the monkeys, who during nearly five months had been equally my companions in misfortune.* These monkeys during our frightful misery had rendered us a service which I scarcely dare mention, and which will scarcely be guessed by the inhabitants of our cities, who look upon these animals as objects of diversion: they freed us from the vermin which infested us, and showed particularly a remarkable cleverness in seeking out the hideous insects which lodged themselves in our hair.

Poor animals! they seem to me very unfortunate in being shut up in the narrow inclosure of the vessel, when, on the neighboring coast, other monkeys, as if to bully them, came on to the branches of the trees, giving innumerable proofs of their agility.

At the commencement of the day, we saw on the road two Kabyls, similar to the soldiers of Jugurtha, whose harsh appearance powerfully allayed our fancy for wandering. In the evening we witnessed a fearful tumult, which appeared to be directed against us. We learnt afterward

* On my return to Paris I hastened to the Jardin des Plantes to pay a visit to the lion, but he received me with a very unamiable gnashing of the teeth. Think, then, of the marvelous history of the Florentine lion, the subject of so many engravings, which is offered on the stall of every print-seller to the eyes of the moved and astonished passers by.

that the Mahomedan priest had been the object of it; that it originated with some Kabyls whom he had disarmed on one of their journeys to Bougie. This incident, which appeared likely to be repeated, inspired us for a moment with the thought of returning; but the sailors were resolute, and we continued our hazardous enterprise.

In proportion as we advanced, our troops became increased by a certain number of Kabyls, who wished to go to Algiers to work there in the quality of seamen, and who dared not undertake alone this dangerous journey.

The third day we encamped in the open air, at the entrance of a forest. The Arabs lighted a very large fire in the form of a circle, and placed themselves in the middle. Toward eleven o'clock I was awakened by the noise which the mules made, all trying to break their fastenings. I asked what was the cause of this disturbance. They answered me that a "*sebâá*" had come roaming in the neighborhood. I was not aware then that a "*sebâá*" was a lion, and I went to sleep again. The next day, in traversing the forest, the arrangement of the caravan was changed. It was grouped in the smallest space possible; one Kabyl was at the head, his gun ready for service; another was in the rear, in the same position. I inquired of the owner of the mule the cause of these unusual precautions. He answered me that they were dreading an attack from a "*sebâá*," and that if this should occur, one of us would be carried off without having time to put himself on the defensive. "I would rather be a spectator," I said to him, "than an actor in the scene you describe; consequently, I will give you two piastres more if you will keep your mule always in the center of the moving group." My proposal was accepted. It was then for the first time that I saw that my Arab carried a yatagan under his tunic, which he used for pricking on the mule the whole time that we were in the thicket. Superfluous cautions! The "*sebâá*" did not show himself.

Each village being a little republic, whose territory we could not cross without obtaining permission and a passport from the Mahomedan priest *président*, the priest who conducted our caravan used to leave us in the fields, and went sometimes a good way off to a village to solicit the permission, without which it would have been dangerous to continue our route. He remained entire hours without returning to us, and we then had occasion to reflect sadly on the imprudence of our enterprise. We generally slept among habitations. Once we found the streets of a village barricaded, because they were fearing an attack from a neighboring village. The foremost man of our caravan removed the obstacles; but a woman came out of her house like a fury, and belabored us with blows from a pole. We remarked that she was fair, of brilliant whiteness, and very pretty.

Another time we lay down in a lurking-place dignified by the beautiful name of Caravanseray. In the morning, when the sun rose, cries of "*Roumi! Roumi!*" warned us that we had been discovered. The sailor,

Mehemet, he who figured in the scene of the oath at Palamos, entered in a melancholy mood the inclosure where we were together, and made us understand that the cries of "Roumi!" vociferated under these circumstances, were equivalent to a sentence of death. "Wait," said he; "a means of saving you has occurred to me." Mehemet entered some moments afterward, told us that his means had succeeded, and invited me to join the Kabyls, who were going to say prayers.

I accordingly went out and prostrated myself toward the east. I imitated minutely the gestures which I saw made around me, pronouncing the sacred words, *La elah il Allah! oua Mahommed raçoul Allah!* It was the scene of Mamamouchi of the "Bourgeois Gentilhomme," which I had so often seen acted by Dugazon, with this one difference, that this time it did not make me laugh. I was, however, ignorant of the consequences it might have brought upon me on my arrival at Algiers. After having made the profession of faith before Mahomedans, *There is but one God, and Mahomet is his prophet*, if I had been informed against to the mufti, I must inevitably have become Mussulman, and they would not have allowed me to go out of the regency.

I must not forget to relate by what means Mehemet had saved us from inevitable death. "You have guessed rightly," said he to the Kabyls, "there are two Christians in the caravansary, but they are Mahomedans at heart, and are going to Algiers to be adopted by the mufti into our holy religion. You will not doubt this when I tell you that I was myself a slave to some Christians, and that they redeemed me with their money." "In cha Allah!" they exclaimed with one voice. And it was then that the scene took place which I have just described.

We arrived in sight of Algiers the 25th December, 1808. We took leave of the Arab owners of our mules, who walked on foot by the side of us, and we spurred them on in order to reach the town before the closing of the gates. On our arrival we learnt that the Dey, to whom we owed our first deliverance, had been beheaded. The guard of the palace before which we passed stopped us and questioned us as to whence we came. We replied that we came from Bougie by land. "It is not possible," exclaimed all the janissaries at once, "the Dey himself would not venture to undertake such a journey." "We acknowledge that we have committed a great imprudence, that we would not undertake to recommence the journey for millions; but the fact that we have just declared is the strict truth."

Arrived at the consular house we were, as on the first occasion, very cordially welcomed. We received a visit from a dragoman sent by the Dey, who asked whether we persisted in maintaining that Bougie had been our point of departure, and not Cape Matifou, or some neighboring part. We again affirmed the truth of our recital; it was confirmed the next day on the arrival of the proprietors of our mules.

At Palamos, during the various interviews which I had with the dowager Duchess of Orleans, one circumstance had particularly affected me.

The princess spoke to me unceasingly of the wish she had to go and rejoin one of her sons, whom she believed to be alive, but of whose death I had been informed by a person belonging to her household. Hence I was anxious to do all that lay in my power to mitigate a sorrow which she must experience before long.

At the moment when I quitted Spain for Marseilles, the duchess confided to me two letters which I was to forward in safety to their addresses. One was destined for the Empress-mother of Russia, the other for the Empress of Austria.

Scarcely had I arrived at Algiers when I mentioned these two letters to M. Dubois Thainville, and begged him to send them to France by the first opportunity. "I shall do nothing of the sort," he at once answered. "Do you know that you have behaved in this affair like a young inexperienced man, or to speak out, like a blunderer? I am surprised that you did not comprehend that the Emperor, with his pettish spirit, might take this much amiss, and consider you, according to the contents of the two letters, as the promoter of an intrigue in favor of the exiled family of the Bourbons." Thus the paternal advice of the French consul taught me that in all that regards politics, however nearly or remotely, one cannot give himself up, without danger, to the dictates of the heart and the reason.

I inclosed my two letters in an envelope bearing the address of a trustworthy person, and gave them into the hands of a corsair, who, after touching at Algiers, would proceed to France. I have never known whether they reached their destination.

The reigning Dey, successor to the beheaded Dey, had formerly filled the humble office of "*épileur*"* of dead bodies in the mosques. He governed the regency with much gentleness, occupying himself with little but his harem. This disgusted those who had raised him to this eminent post, and they resolved upon getting rid of him. We became aware of the danger which menaced him, by seeing the courts and vestibules of the consular house full, according to the custom under such circumstances, of Jews, carrying with them whatever they had of most value. It was a rule at Algiers that all that happened in the interval comprised between the death of a Dey and the installation of his successor could not be followed up by justice, and must remain unpunished. One can imagine, then, why the children of Moses should seek safety in the consular houses, the European inhabitants of which had the courage to arm themselves for self-defense as soon as the danger was apparent, and who, moreover, had a janissary to guard them.

While the unfortunate Dey "épileur" was being conducted toward the place where he was to be strangled, he heard the cannon which announced his death and the installation of his successor. "They are in great haste," said he, "what will you gain by carrying matters to ex-

*An "*épileur*" is a person who removes superfluous hairs. We have been unable to ascertain what office of this kind is performed in Mohamedan funerals.

tremities? Send me to the Levant; I promise you never to return. What have you to reproach me with?" "With nothing," answered his escort, "but your insignificance. However, a man cannot live as a mere private man, after having been Dey of Algiers." And the unfortunate man perished by the rope.

The communication by sea between Bougie and Algiers was not so difficult, even with the "*sandalas*," as the Caïd of the former town wished to assure me. Captain Spiro had the cases landed which belonged to me. The Caïd sought to discover what they contained; and having perceived through a chink something yellowish, he hastened to send the news to the Dey, that the Frenchmen who had come to Algiers by land had among their baggage cases filled with zechins, destined to revolutionize the Kabylie. They immediately had these cases forwarded to Algiers, and at their opening before the minister of naval affairs, all the phantasmagoria of zechins, of treasure, of revolution, disappeared at the sight of the stands and the limbs of several repeating circles in copper.

We are now going to sojourn several months in Algiers. I will take advantage of this to put together some details of manners, which may be interesting as the picture of a state of things anterior to that of the occupation of the regency by the French. This occupation, it must be remarked, has already fundamentally altered the manners and the habits of the Algerine population.

I am about to report a curious fact, and one which shows that politics, which insinuate themselves and bring discord into the bosom of the most united families, had succeeded, strange to say, in penetrating as far as the galley-slaves' prison at Algiers. The slaves belonged to three nations; there were in 1809 in this prison, Portuguese, Neapolitans, and Sicilians; among these two latter classes were counted partisans of Murat and those of Ferdinand of Naples. One day, at the beginning of the year, a dragoman came in the name of the Dey to beg M. Dubois Thainville to go without delay to the prison, where the friends of the French and their adversaries had involved themselves in a furious combat; and already several had fallen. The weapon with which they struck each other was the heavy long chain attached to their legs.

Each consul, as I said above, had a janissary placed with him as his guard; the one belonging to the French consul was a Candiote; he had been surnamed The Terror. Whenever some news unfavorable to France was announced in the cafés, he came to the consulate to inform himself as to the reality of the fact; and when we told him that the other janissaries had propagated false news, he returned to them, and there, yatagan in hand, he declared himself ready to enter the lists in combat against those who should still maintain the truth of the news. As these continual threats might endanger him (for they had no support beyond his mere animal courage) we had wished to render him expert in the handling of arms by giving him some lessons in fencing; but he could

not endure the idea that Christians should touch him at every turn with foils; he therefore proposed to substitute for the simulated duel a real combat with the yatagan.

One may gain an exact idea of this savage nature when I mention that, having one day heard a pistol-shot, the sound of which proceeded from his room, people ran and found him bathed in his blood; he had just shot off a ball into his arm to cure himself of a rheumatic pain.

Seeing with what facility the Deys disappeared, I said one day to our janissary, "With this prospect before your eyes, would you consent to become Dey?" "Yes, doubtless," answered he. "You seem to count as nothing the pleasure of doing all that one likes, if only even for a single day!"

When we wished to take a turn in the town of Algiers, we generally took care to be escorted by the janissary attached to the consular house; it was the only means of escaping insults, affronts, and even acts of violence. I have just said it was the only means. I made a mistake; there was one other; that was, to go in the company of a French "lazarist" of seventy years of age, and whose name, if my memory serves me, was Father Joshua; he had lived in this country for a half a century. This man, of exemplary virtue, had devoted himself with admirable self-denial to the service of the slaves of the regency, and had divested himself of all considerations of nationality; the Portuguese, Neapolitans, Sicilians, all were equally his brethren.

In the times of plague he was seen day and night carrying eager help to the Mussulmans; thus his virtue had conquered even religious hatreds; and wherever he passed he and the persons who might accompany him received from multitudes of the people, from the janissaries, and even from the officials of the mosques, the most respectful salutations.

During our long hours of sailing on board the Algerine vessel, and our compulsory stay in the prisons at Rosas, and on the hulk at Palamos, I gathered some ideas as to the interior life of the Moors or the Coulougous, which, even now when Algiers has fallen under the dominion of France, would, perhaps, be yet worth preserving. I shall, however, confine myself to recounting nearly word for word, a conversation which I had with Raïs Braham, whose father was a "*Turc fin*," that is to say, a Turk born in the Levant.

"How is it that you consent," said I to him, "to marry a young girl whom you have never seen, and find in her, perhaps, an excessively ugly woman, instead of the beauty whom you had fancied to yourself?"

"We never marry without having obtained information from the women who serve in the capacity of servants at the public baths. The Jewesses are, moreover, in these cases very useful go-betweens."

"How many legitimate wives have you?"

"I have four—that is to say, the number authorized by the Koran."

"Do they live together on a good understanding?"

"Ah, sir, my house is a hell. I never enter it without finding them at the step of the door, or at the bottom of the stairs; then each wants to be the first to make me listen to the complaints which she has to bring against her companions. I am about to utter blasphemy, but I think that our holy religion ought to prohibit a plurality of wives to those who are not rich enough to give to each a separate habitation."

"But since the Koran allows you to repudiate even legitimate wives, why do you not send back three of them to their parents?"

"Why? Because that would ruin me. On the day of the marriage the father of the young woman to be married stipulates for a dowry, and the half of it is paid. The other half may be exacted the day that the woman is repudiated. It would then be three half-dowries that I should have to pay if I sent back three of my wives. I ought, however, to rectify one inaccuracy in what I said just now, that my four wives had never agreed together. Once they were agreed among themselves in the feeling of a common hatred. In going through the market I had bought a young negress. In the evening, when I retired to rest, I perceived that my wives had prepared no bed for her, and that the unfortunate girl was extended on the ground. I rolled up my trowsers and laid them under her head as a kind of pillow. In the morning the distracting cries of the poor slave made me run to her, and I found her nearly sinking under the blows of my four wives; for once they understood each other marvelously well."

In February, 1809, the new Dey, the successor of the "épileur," a short time after having entered on his functions, claimed from two to three hundred thousand francs—I do not remember exactly the sum—which he pretended was due to him from the French government. M. Dubois Thainville answered that he had received the Emperor's orders not to pay one centime.

The Dey was furious, and decided upon declaring war against us. A declaration of war at Algiers used to be immediately followed by putting all the persons of other nations into prison. This time matters were not pushed to this extreme limit. Our names might be figuring on the list of the slaves of the regency; but, in fact, so far as I was concerned, I remained free in the consular house. By means of a pecuniary guarantee, contracted with the Swedish consul, M. Nörderling, I was even permitted to live at his country-house, situated near the Emperor's fort.

The most insignificant event was sufficient to modify the ideas of these barbarians. I had come into the town one day, and was seated at table at M. Dubois Thainville's, when the English consul, Mr. Blankley, arrived in great haste, announcing to our consul the entrance into the port of a French prize. "I never will uselessly add," said he, generously, "to the severities of war; I came to announce to you, my colleague, that I will give up your prisoners on a receipt which will insure me the deliverance of an equal number of Englishmen detained in

France." "I thank you," answered M. Dubois Thainville; "but I do not the less deplore this event that it will retard, indefinitely perhaps, the settlement of the account in which I am engaged with the Dey."

During this conversation, armed with a telescope, I was looking through the window of the dining-room, trying to persuade myself at least that the captured vessel was not one of much importance. But one must yield to evidence. It was pierced for a great number of guns. All at once, the wind having displayed the flags, I perceived with surprise the French flag over the English flag. I communicated what I observed to Mr. Blankley. He answered immediately, "You do not surely pretend to observe better with your bad telescope than I did with my *Dolland?*"

"And you cannot pretend," said I to him in *my* turn, "to see better than an astronomer by profession? I am sure of my fact. I beg M. Thainville's permission, and will go this instant to visit this mysterious prize."

In short, I went there; and this is what I learnt:

General Duhesme, Governor of Barcelona, wishing to rid himself of the most ill-disciplined portion of his garrison, formed the principal part into the crew of a vessel, the command of which he gave to a lieutenant of Babastro, a celebrated corsair of the Mediterranean.

There were among these improvised seamen a hussar, a dragoon, two veterans, a miner with his long beard, &c. The vessel, leaving Barcelona by night, escaped the English cruiser, and got to the entrance of Port Mahon. An English "lettre de marque" was coming out of the port. The crew of the French vessel boarded her; and a furious combat on the deck ensued, in which the French got the upper-hand. It was this "lettre de marque" which had now arrived at Algiers.

Invested with full power by M. Dubois Thainville, I announced to the prisoners that they were about to be immediately given up to their consul. I respected even the trick of the captain, who, wounded by several saber cuts, had contrived to cover up his head with his principal flag. I reassured his wife; but my chief care was especially devoted to a passenger whom I saw, with one arm amputated.

"Where is the surgeon," I said to him, "who operated on you?"

"It was not our surgeon," he answered. "He basely fled with a part of the crew, and saved himself on land."

"Who, then, cut off your arm?"

"It was the hussar whom you see here."

"Unhappy man! I exclaimed, "what could lead you, when it was not your profession, to perform this operation?"

"The pressing request of the wounded man. His arm had already swollen to an enormous size. He wanted some one to cut it off for him with a blow of a hatchet. I told him that in Egypt, when I was in hospital, I had seen several amputations made; that I would imitate what I had seen, and might perhaps succeed That at any rate it would be

better than the blow of a hatchet. All was agreed; I armed myseif with the carpenter's saw, and the operation was done."

I went off immediately to the American consul to claim the assistance of the only surgeon worthy of confidence who was then in Algiers. Mr. Triplet—I think I recollect that that was the name of the man of the distinguished art whose aid I invoked—came at once on board the vessel, examined the dressing of the wound, and declared, to my very lively satisfaction, that all was going on well, and that the Englishman would survive his horrible injury.

The same day we had the wounded men carried on litters to Mr. Blankley's house; this operation, executed with somewhat of ceremony, modified, though slightly, the feelings of the Dey in our favor, and his sentiments became yet more favorable toward us in consequence of another maritime occurrence, although a very insignificant one.

One day a corvette was seen in the horizon armed with a very great number of guns, and shaping her way toward the port of Algiers; there appeared immediately after an English brig of war in full sail; a combat was, therefore, expected, and all the terraces of the town were covered with spectators. The brig appeared to be the best sailer, and seemed to us likely to reach the corvette, but the latter tacked about, and seemed desirous to engage in battle; the English vessel fled before her; the corvette tacked about the second time, and again directed her course toward Algiers, where, one would have supposed, she had some special mission to execute. The brig in her turn now changed her course, but held herself constantly beyond the reach of shot from the corvette; at last the two vessels arrived in succession in the port, and cast anchor, to the lively disappointment of the Algerine population, who had hoped to be present without danger at a maritime combat between the "Christian dogs," belonging to two nations equally detested in a religious point of view; but shouts of laughter could not be repressed when it was seen that the corvette was a merchant vessel, and that she was only armed with wooden imitations of cannon. It was said in the town that the English sailors were furious, and had been on the point of mutiny against their too prudent captain.

I have very little to tell in favor of the Algerines; hence I must do an act of justice by mentioning that the corvette departed the next day for the Antilles, her destination, and that the brig was not permitted to set sail until the next day but one.

Bakri often came to the French consulate to talk of our affairs with M. Dubois Thainville. "What can you want?" said the latter; "you are an Algerine; you will be the first victim of the Dey's obstinacy. I have already written to Livorno that your families and your goods are to be seized. When the vessels laden with cotton, which you have in this port, arrive at Marseilles, they will be immediately confiscated; it is for you to judge whether it would not better suit you to pay the sum which the Dey claims than to expose yourself to tenfold and certain loss."

Such reasoning was unanswerable; and whatever it might cost him, Bakri decided on paying the sum that was demanded of France.

Permission to depart was immediately granted to us; I embarked the 21st of June, 1809, on board a vessel in which M. Dubois Thainville and his family were passengers.

The evening before our departure from Algiers, a corsair deposited at the consul's the Majorcan mail, which he had taken from a vessel which he had captured. It was a complete collection of the letters which the inhabitants of the Baléares had been writing to their friends on the Continent.

"Look here," said M. Dubois Thainville to me, "here is something to amuse you during the voyage, you who generally keep your room from sea-sickness; break the seals and read all these letters, and see whether they contain any accounts by which we might profit how to aid the unhappy soldiers who are dying of misery and despair in the little island of Cabrera."

Scarcely had we arrived on board the vessel, when I set myself to the work, and acted without scruple or remorse the part of an official of the black chamber, with this sole difference, that the letters were unsealed without taking any precautions. I found among them several dispatches in which Admiral Collingwood signified to the Spanish government the ease with which the prisoners might be delivered. Immediately on our arrival at Marseilles these letters were sent to the minister of naval affairs, who, I believe, did not pay much attention to them.

I knew almost every one at Palma, the capital of Majorca. I leave it to be imagined with what curiosity I read the missives in which the beautiful ladies of the town expressed their hatred against *los malditos cavachios*, (French,) whose presence in Spain had rendered necessary the departure for the Continent of a magnificent regiment of hussars; how many persons might I not have embroiled, if under a mask I had found myself with them at the opera ball!

Many of the letters made mention of me, and were particularly interesting to me; I was sure in this instance there was nothing to constrain the frankness of those who had written them. It is an advantage which few people can boast having enjoyed to the same degree.

The vessel in which I was, although laden with bales of cotton, had some corsair papers of the regency, and was the reputed escort of three richly laden merchant vessels which were going to France.

We were off Marseilles on the 1st of July, when an English frigate came to stop our passage: "I will not take you," said the English captain, "but you will go towards the Hyères Islands, and Admiral Collingwood will decide on your fate."

"I have received," answered the Barbary captain, "an express commission to conduct these vessels to Marseilles, and I will execute it."

"You, individually, can do what may seem to you best," answered the Englishman; "as to the merchant vessels under your escort, they will

be, I repeat to you, taken to Admiral Collingwood." And he immediately gave orders to those vessels to set sail to the east.

The frigate had already gone a little distance when she perceived that we were steering toward Marseilles. Having then learnt from the crews of the merchant vessels that we were ourselves laden with cotton, she tacked about to seize us.

She was very near reaching us, when we were enabled to enter the port of the little island of Pomègue. In the night she put her boats to sea to try to carry us off; but the enterprise was too perilous, and she did not dare attempt it.

The next morning, 2d of July, 1809, I disembarked at the lazaretto.

At the present day they go from Algiers to Marseilles in four days; it had taken me eleven months to make the same voyage. It is true that here and there I had made involuntary sojourns.

My letters sent from the lazaretto at Marseilles were considered by my relatives and friends as certificates of resurrection, they having for a long time past supposed me dead. A great geometer had even proposed to the Bureau of Longitude no longer to pay my allowance to my authorized representative; which appears the more cruel inasmuch as this representative was my father.

The first letter which I received from Paris was full of sympathy and congratulations on the termination of my laborious and perilous adventures; it was from a man already in possession of an European reputation, but whom I had never seen: M. de Humboldt, after what he had heard of my misfortunes, offered me his friendship. Such was the first origin of a connection which dates from nearly forty-two years back, without a single cloud ever having troubled it.

M. Dubois Thainville had numerous acquaintances in Marseilles; his wife was a native of that town, and her family resided there. They received, therefore, both of them, numerous visits in the parlor of the lazaretto. The bell which summoned them, for me alone was dumb; and I remained as solitary and forsaken, at the gates of a town peopled with a hundred thousand of my countrymen, as if I had been in the heart of Africa. One day, however, the parlor bell rang three times, (the number of times corresponding to the number of my room;) I thought it must be a mistake; I did not, however, allow this to appear. I traversed proudly under the escort of my guard of health the long space which separates the lazaretto, properly so called, from the parlor, and there I found, with very lively satisfaction, M. Pons, the director of the observatory at Marseilles, and the most celebrated discoverer of comets of whom the annals of astronomy have ever had to register the success.

At any time a visit from the excellent M. Pons, whom I have since seen director of the observatory at Florence, would have been very agreeable to me; but during my quarantine I felt it unappreciably valuable. It proved to me that I had returned to my native soil.

Two or three days before our admission to freedom, we experienced a loss which was deeply felt by each of us. To pass away the heavy time of a severe quarantine, the little Algerine colony was in the habit of going to an inclosure near the lazaretto, where a very beautiful gazelle, belonging to M. Dubois Thainville, was confined; she bounded about there in full liberty with a grace which excited our admiration. One of us endeavored to stop this elegant animal in her course; he seized her unluckily by the leg, and broke it. We all ran, but only, alas! to witness a scene which excited the deepest emotion in us.

The gazelle, lying on her side, raised her head sadly; her beautiful eyes (the eyes of a gazelle!) shed torrents of tears; no cry of complaint escaped her mouth; she produced that effect upon us which is always felt when a person who is suddenly struck by an irreparable misfortune, resigns himself to it, and shows his profound anguish only by silent tears.

Having ended my quarantine, I went at once to Perpignan, to the bosom of my family, where my mother, the most excellent and pious of women, caused numerous masses to be said to celebrate my return, as she had done before to pray for the repose of my soul, when she thought that I had fallen under the daggers of the Spaniards. But I soon quitted my native town to return to Paris; and I deposited at the Bureau of Longitude and the Academy of Sciences my observations, which I had succeeded in preserving amidst the perils and tribulations of my long campaign.

A few days after my arrival, on the 18th of September, 1809, I was nominated an academician in the place of Lalande. There were fifty-two voters; I obtained forty-seven voices, M. Poisson four, and M. Nouet one. I was then twenty-three years of age.

A nomination made with such a majority would appear, at first sight, as if it would give rise to no serious difficulties; but it proved otherwise. The intervention of M. de Laplace, before the day of ballot, was active and incessant to have my admission postponed until the time when a vacancy, occurring in the geometry section, might enable the learned assembly to nominate M. Poisson at the same time as me. The author of the *Mécanique Céleste* had vowed to the young geometer an unbounded attachment, completely justified, certainly, by the beautiful researches which science already owed to him. M. de Laplace could not support the idea that a young astronomer, younger by five years than M. Poisson, a pupil, in the presence of his professor at the Polytechnic School, should become an academician before him. He proposed to me, therefore, to write to the Academy that I would not stand for election until there should be a second place to give to Poisson. I answered by a formal refusal, and giving my reasons in these terms: "I care little to be nominated at this moment. I have decided upon leaving shortly with M. de Humboldt for Thibet. In those savage regions the title of member of the Institute will not smooth the difficulties which we shall have to encounter. But

I would not be guilty of any rudeness toward the Academy. If they were to receive the declaration for which I am asked, would not the savans who composed this illustrious body have a right to say to me: "How are you certain that we have thought of you? You refuse what has not yet been offered to you.'"

On seeing my firm resolution not to lend myself to the inconsiderate course which he had advised me to follow, M. de Laplace went to work in another way: he maintained that I had not sufficient distinction for admission into the Academy. I do not pretend that, at the age of three-and-twenty, my scientific attainments were very considerable, if estimated in an *absolute* manner; but when I judged by *comparison*, I regained courage, especially on considering that the three last years of my life had been consecrated to the measurement of an arc of the meridian in a foreign country; that they were passed amid the storms of the war with Spain; often enough in dungeons, or, what was yet worse, in the mountains of Kabylia, and at Algiers, at that time a very dangerous residence.

Here is, therefore, my statement of accounts for that epoch. I make it over to the impartial appreciation of the reader:

On leaving the Polytechnic School, I had made, in conjunction with M. Biot, an extensive and very minute research on the determination of the coefficient of the tables of atmospheric refraction.

We had also measured the refraction of different gases, which, up to that time, had not been attempted.

A determination, more exact than had been previously obtained, of the relation of the weight of air to the weight of mercury, had furnished a direct value of the coefficient of the barometrical formula which served for the calculation of the heights.

I had contributed, in a regular and very assiduous manner, during nearly two years, to the observations which were made day and night with the transit telescope and with the mural quadrant at the Paris Observatory.

I had undertaken, in conjunction with M. Bouvard, the observations relating to the verification of the laws of the moon's libration. All the calculations were prepared; it only remained for me to put the numbers into the formulæ, when I was, by order of the Bureau of Longitude, obliged to leave Paris for Spain. I had observed various comets, and calculated their orbits. I had, in concert with M. Bouvard, calculated, according to Laplace's formula, the table of refraction which has been published in the *Recueil des Tables* of the Bureau of Longitude, and in the *Connaissance des Temps*. A research on the velocity of light, made with a prism placed before the object end of the telescope of the mural circle, had proved that the same tables of refraction might serve for the sun and all the stars.

Finally, I had just terminated, under very difficult circumstances, the

grandest triangulation which had ever been achieved, to prolong the meridian line from France as far as the Island of Formentera.

M. de Laplace, without denying the importance and utility of these labors and these researches, saw in them nothing more than indications of promise; M. Lagrange then said to him explicitly:

"Even you, M. de Laplace, when you entered the Academy, had done nothing brilliant; you only gave promise. Your grand discoveries did not come till afterward."

Lagrange was the only man in Europe who could with authority address such an observation to him.

M. de Laplace did not reply upon the ground of the personal question, but he added, "I maintain that it is useful to young savans to hold out the position of member of the Institute as a future recompense, to excite their zeal."

"You resemble," replied M. Hallé, "the driver of the hackney coach, who, to excite his horses to a gallop, tied a bundle of hay at the end of his carriage pole; the poor horses redoubled their efforts, and the bundle of hay always flew on before them. After all, his plan made them fall off, and soon after brought on their death."

Delambre, Legendre, Biot, insisted on the devotion, and what they termed the courage, with which I had combated arduous difficulties, whether in carrying on the observations, or in saving the instruments and the results already obtained. They drew an animated picture of the dangers I had undergone. M. de Laplace ended by yielding when he saw that all the most eminent men of the Academy had taken me under their patronage, and on the day of the election he gave me his vote. It would be, I must own, a subject of regret with me even to this day, after a lapse of forty-two years, if I had become member of the Institute without having obtained the vote of the author of the *Mécanique Céleste*.

The members of the Institute were always presented to the Emperor after he had confirmed their nominations. On the appointed day, in company with the presidents, with the secretaries of the four classes, and with the academicians who had special publications to offer to the Chief of the State, they assembled in one of the saloons of the Tuileries. When the Emperor returned from mass, he held a kind of review of these savans, these artists, these literary men, in green uniform.

I must own that the spectacle which I witnessed on the day of my presentation did not edify me. I even experienced real displeasure in seeing the anxiety evinced by members of the Institute to be noticed.

"You are very young," said Napoleon to me on coming near me; and without waiting for a flattering reply, which it would not have been difficult to find, he added, "What is your name?" And my neighbor on the right, not leaving me time to answer the simple enough question just addressed to me, hastened to say:

"*His* name is Arago."

"What science do you cultivate?"

My neighbor on the left immediately replied—

"*He* cultivates astronomy."

"What have you done?"

My neighbour on the right, jealous of my left hand neighbor for having encroached on his rights at the second question, now hastened to reply, and said:

"*He* has just been measuring the line of the meridian in Spain."

The Emperor, imagining doubtless that he had before him either a dumb man or an imbecile, passed on to another member of the Institute. This one was not a novice, but a naturalist well known through his beautiful and important discoveries, it was M. Lamarck. The old man presented a book to Napoleon.

"What is that?" said the latter, "it is your absurd *meteorology*, in which you rival Matthieu Laensberg. It is this 'annuaire' which dishonors your old age. Do something in natural history, and I should receive your productions with pleasure. As to this volume, I only take it in consideration of your white hair. Here!" And he passed the book to an aide-de-camp.

Poor M. Lamarck, who, at the end of each sharp and insulting sentence of the Emperor, tried in vain to say, "It is a work on natural history which I present to you," was weak enough to fall into tears.

The Emperor immediately afterward met with a more energetic antagonist in the person of M. Lanjuinais. The latter had advanced, book in hand. Napoleon said to him, sneeringly:

"The entire Senate, then, is to merge in the Institute?" "Sire," replied Lanjuinais, "it is the body of the state to which most time is left for occupying itself with literature."

The Emperor, displeased at this answer, at once quitted the civil uniforms, and busied himself among the great epaulettes which filled the room.

Immediately after my nomination I was exposed to strange annoyances on the part of the military authorities. I had left for Spain, still holding the title of pupil of the Polytechnic School. My name could not remain on the books more than four years; consequently I had been enjoined to return to France to go through the examinations necessary on quitting the school. But in the meantime Lalande died, and thus a place in the Bureau of Longitude became vacant. I was named assistant astronomer. These places were submitted to the nomination of the Emperor. M. Lacuée, director of the conscription, thought that, through this latter circumstance, the law would be satisfied, and I was authorized to continue my operations.

M. Matthieu Dumas, who succeeded him, looked at the question from an entirely different point of view; he enjoined me either to furnish a substitute, or else set off myself with the contingent of the twelfth arrondissement of Paris.

All my remonstrances and those of my friends having been fruitless, I announced to the honorable general that I should present myself in the Place de l'Estrapade, whence the conscripts had to depart, in the costume of a member of the Institute; and that thus I should march on foot through the city of Paris. General Matthieu Dumas was alarmed at the effect which this scene would produce on the Emperor, himself a member of the Institute, and hastened, under fear of my threat, to confirm the decision of General Lacuée.

In the year 1809, I was chosen by the "conseil du perfectionnement" of the Polytechnic School to succeed M. Monge, in his chair of analysis applied to geometry. The circumstances attending that nomination have remained a secret; I seize the first opportunity which offers itself to me to make them known.

M. Monge took the trouble to come to me one day, at the observatory, to ask me to succeed him. I declined this honor, because of a proposed journey which I was going to make into Central Asia with M. de Humboldt. "You will certainly not set off for some months to come," said the illustrious geometer; "you could, therefore, take my place temporarily." "Your proposal," I replied, "flatters me infinitely; but I do not know whether I ought to accept it. I have never read your great work on partial differential equations; I do not, therefore, feel certain that I should be competent to give lessons to the pupils of the Polytechnic School on such a difficult theory." "Try," said he, "and you will find that that theory is clearer than it is generally supposed to be." Accordingly, I did try; and M. Monge's opinion appeared to me to be well founded.

The public could not comprehend, at that time, how it was that the benevolent M. Monge obstinately refused to confide the delivery of his course to M. Binet, (a private teacher under him,) whose zeal was well known. It is this motive which I am going to reveal.

There was then in the "Bois de Boulogne" a residence named the Grey House, where there assembled around M. Coessin, the high-priest of a new religion, a number of adepts, such as Lesueur, the musician, Colin, private teacher of chemistry at the school, M. Binet, &c. A report from the prefect of police had signified to the Emperor that the frequenters of the Grey House were connected with the Society of Jesuits. The Emperor was uneasy and irritated at this. "Well," said he to M. Monge, "there are your dear pupils become disciples of Loyola!" And on Monge's denial, "You deny it," answered the Emperor; "well, then, know that the private teacher of your course is in that clique." Every one can understand that after such a remark, Monge could not consent to being succeeded by M. Binet.

Having entered the Academy, young, ardent, and impassioned, I took much greater part in the nominations than may have been suitable for my position and my time of life. Arrived at an epoch of life whence I examine retrospectively all my actions with calmness and impartiality,

I can render this amount of justice to myself, that, excepting in three or four instances, my vote and interest were always in favor of the most deserving candidate, and more than once I succeeded in preventing the Academy from making a deplorable choice. Who could blame me for having maintained with energy the election of Malus, considering that his competitor, M. Girard, unknown as a physicist, obtained twenty-two votes out of fifty-three, and that an addition of five votes would have given him the victory over the savant who had just discovered the phenomenon of polarization by reflection, over the savant whom Europe would have named by acclamation? The same remarks are applicable to the nomination of Poisson, who would have failed against this same M. Girard if four votes had been otherwise given. Does not this suffice to justify the unusual ardor of my conduct? Although in a third trial the majority of the Academy was decided in favor of the same engineer, I cannot regret that I supported up to the last moment with conviction and warmth the election of his competitor, M. Dulong.

I do not suppose that, in the scientific world, any one will be disposed to blame me for having preferred M. Liouville to M. de Pontécoulant.

Sometimes it happened that the government wished to influence the choice of the Academy; with a strong sense of my rights I invariably resisted all dictation. Once this resistance acted unfortunately on one of my friends—the venerable Legendre; as to myself, I had prepared myself beforehand for all the persecutions of which I could be made the object. Having received from the minister of the interior an invitation to vote for M. Binet against M. Navier on the occurrence of a vacant place in the section of mechanics, Legendre nobly answered that he would vote according to his soul and his conscience. He was immediately deprived of a pension which his great age and his long services rendered due to him. The *protégé* of the authorities failed; and, at the time, this result was attributed to the activity with which I enlightened the members of the Academy as to the impropriety of the minister's proceedings.

On another occasion the King wished the Academy to name Dupuytren, the eminent surgeon, but whose character at the time lay under grave imputations. Dupuytren was nominated, but several blanks protested against the interference of the authorities in academic elections.

I said above that I had saved the Academy from some deplorable choices; I will only cite a single instance, on which occasion I had the sorrow of finding myself in opposition to M. de Laplace. The illustrious geometer wished a vacant place in the astronomical section to be granted to M. Nicollet—a man without talent. At the close of a contest, which I maintained undisguisedly, notwithstanding the danger which might follow from thus braving the powerful protectors of M. Nicollet, the Academy proceeded to the ballot; the respected M. Damoiseau, whose election I had supported, obtained forty-five votes out of forty-eight. Thus M. Nicollet had collected but three.

"I see," said M. de Laplace to me, "that it is useless to struggle

against young people; I acknowledge that the man who is called the *great elector* of the Academy is more powerful than I am."

"No," replied I; "M. Arago can only succeed in counterbalancing the opinion justly preponderating for M. de Laplace, when the right is found to be without possible contradiction on his side."

I would warn those savants, who having early entered the Academy, might be tempted to imitate my example, to expect nothing beyond the satisfaction of their conscience. I warn them, with a knowledge of the case, that gratitude will almost always be found wanting.

The elected Academician, whose merits you have sometimes exalted beyond measure, pretends that you have done no more than justice to him; that you have only fulfilled a duty, and that he therefore owes you no thanks.

Delambre died the 19th August, 1822. After the necessary delay, they proceeded to fill his place. The situation of perpetual secretary is not one which can long be left vacant. The Academy named a commission to present it with candidates; it was composed of Messrs. de Laplace, Arago, Legendre, Rossel, Prony, and Lacroix. The list presented was composed of the names of Messrs. Biot, Fourier, and Arago. It is not necessary for me to say with what obstinacy I opposed the inscription of my name on this list; I was compelled to give way to the will of my colleagues, but I seized the first opportunity of declaring publicly that I had neither the expectation nor the wish to obtain a single vote; that, moreover, I had on my hands already as much work as I could get through; that in this respect M. Biot was in the same position; and that, in short, I should vote for the nomination of M. Fourier.

It was supposed, but I dare not flatter myself that it was the fact, that my declaration exercised a certain influence on the result of the ballot. The result was as follows: M. Fourier received thirty-eight votes, and M. Biot ten. In a case of this nature each man carefully conceals his vote, in order not to run the risk of future disagreement with him who may be invested with the authority which the Academy gives to the perpetual secretary. I do not know whether I shall be pardoned if I recount an incident which amused the Academy at the time.

M. de Laplace, at the moment of voting, took two plain pieces of paper; his neighbor was guilty of the indiscretion of looking, and saw distinctly that the illustrious geometer wrote the name of Fourier on both of them. After quietly folding them up, M. de Laplace put the papers into his hat, shook it, and said to this same curious neighbor: "You see, I have written two papers; I am going to tear up one; I shall put the other into the urn; I shall thus be myself ignorant for which of the two candidates I have voted."

All went on as the celebrated Academician had said; only that every one knew with certainty that his vote had been for Fourier; and "the calculation of probabilities" was in no way necessary for arriving at this result.

After having fulfilled the duties of secretary with much distinction, but not without some feebleness and negligence in consequence of his bad health, Fourier died the 16th of May, 1830. I declined several times the honor which the Academy appeared willing to do me, in naming me to succeed him. I believed, without false modesty, that I had not the qualities necessary to fill this important place suitably. When thirty-nine out of forty-four voters had appointed me, it was quite time that I should give in to an opinion so flattering and so plainly expressed. On the 7th of June, 1830, I, therefore, became perpetual secretary of the Academy for the Mathematical Sciences; but, conformably to the plea of an accumulation of offices, which I had used as an argument to support, in November, 1822, the election of M. Fourier, I declared that I should give in my resignation of the professorship in the Polytechnic School. Neither the solicitations of Marshal Soult, the minister of war, nor those of the most eminent members of the Academy, could avail in persuading me to renounce this resolution.

HERSCHEL.

By M. Arago.

William Herschel, one of the greatest astronomers that ever lived in any age or country, was born at Hanover, on the 15th of November, 1738. The name of Herschel has become too illustrious for the world to neglect searching back, along the stream of time, to learn the social position of the families that have borne it. Yet pardonable curiosity on this subject has not been entirely satisfied. We only know that Abraham Herschel, great-grandfather of the astronomer, resided at Mähren, whence he was expelled on account of his strong attachment to the Protestant faith; that Abraham's son Isaac was a farmer in the vicinity of Leipzig; that Isaac's eldest son, Jacob Herschel, disappointed his father's earnest desire to see him devote himself to agriculture, that he determined on being a musician, and settled at Hanover.

Jacob Herschel, father of William, the astronomer, was an eminent musician, not less remarkable for the good qualities of his heart than for those of his mind. His very limited means did not enable him to bestow a complete education on his family, consisting of six boys and four girls, although, by his care, his ten children all became excellent musicians. The eldest, Jacob, even acquired a rare degree of skill, which procured for him the appointment of master of the band in a Hanoverian regiment, which he accompanied to England. The third son, William, remained under his father's roof, and, without neglecting the fine arts, took lessons in the French language, and devoted himself to the study of metaphysics, for which he retained a taste to his latest day.

In 1759 William Herschel, then about twenty-one years of age, went over to England, not with his father, as has been erroneously stated. but with his brother Jacob, whose connections in that country seemed likely to favor the young man's opening prospects in life. But neither London nor the country towns afforded him any resource in the beginning, and the first two or three years after his expatriation were marked with cruel privations, which were, however, manfully endured. A fortunate chance finally raised the young Hanoverian to a better position; Lord Durham engaged him as master of the band in an English regiment which was quartered on the borders of Scotland. From this moment he began to acquire a reputation as a musician that was gradually extended, until in 1766 he was appointed organist at Halifax, (Yorkshire.) The emoluments of this situation, together with those of giving private lessons both in the town and the country around, afforded him the means to remedy, or rather to complete, his early education. It was

then that he learned Latin and Italian, though without any other help than a grammar and a dictionary, and that he also acquired some knowledge of Greek. So great was the desire for knowledge with which he was inspired that while residing at Halifax he found means to continue his philological exercises, and at the same time to study deeply the learned but very obscure mathematical work of Smith on the theory of music. This treatise, either explicitly or implicitly, supposed the reader to have a knowledge of algebra and geometry, which Herschel did not possess, but of which he made himself master in a very short time.

In 1766 Herschel obtained the appointment of organist to the Octagon Chapel at Bath. This was a more lucrative post than that at Halifax, but it also devolved on him new obligations. He had to play incessantly either at the oratorios, or in the rooms at the baths, at the theater, and in the public concerts. Besides this, from among his patrons in the most fashionable circle of England, he could not refuse to take numerous pupils who wished to be instructed in his art. It is difficult to imagine how, among so many duties, so many distractions of various kinds, Herschel could continue the studies, which even at Halifax had required so much resolution and perseverance, with a very uncommon degree of talent. We have seen that it was by music that Herschel was led to mathematics; mathematics in their turn led him to optics, the principal and fertile source of his illustrious career. The time finally arrived when his theoretic knowledge was to guide the young musician into a laborious application of principles quite foreign to his habits; and of which the brilliant success, as well as the excessive temerity, must excite reasonable astonishment.

A telescope—a simple reflector, only two English feet in length falls into the hands of Herschel during his residence at Bath. This instrument, however imperfect, shows him a multitude of stars in the sky that the naked eye cannot discern; shows him also enlarged known objects, under their true dimensions; reveals forms to him that the richest imaginations of antiquity had never suspected. He is transported with enthusiasm, and resolves, without delay, to have a similar instrument but of larger size. The answer from London is delayed for some days. These few days appear to him as years. When the answer arrives, the price that the optician demands proves to be much beyond the pecuniary resources of a mere organist. To any other man this would have been an unsurmountable obstacle. This unexpected difficulty, on the contrary, inspired Herschel with fresh energy. He cannot buy a telescope; then he will construct one with his own hands. The musician of the Octagon Chapel rushes immediately into a multitude of experiments, on metallic alloys that reflect light with the greatest intensity, on the means of giving the parabolic figure to the mirrors, on the causes that in the operation of polishing affect the regularity of the reflection, &c. So rare a degree of perseverance at last receives its reward. In 1774 Herschel has the happiness of being

able to examine the heavens with a Newtonian telescope of five English feet focus, entirely made by himself. This success tempts him to undertake still more difficult enterprises. Other telescopes of seven, of eight, of ten, and even of twenty feet focal distance, crown his efforts. As if to answer in advance those critics who would have accused him of a superfluity of apparatus, of unnecessary luxury, in the large size of the new instruments, and his extreme minutiæ in their execution, Nature granted to the astronomical musician, on the 13th of March, 1781, the unprecedented honor of commencing his career of observation with the discovery of a new planet, situated on the confines of our solar system. Dating from that moment, Herschel's reputation, no longer in his character of musician, but as a constructor of telescopes and as an astronomer, spread throughout the world. George III, a lover of science, and much inclined besides to protect and patronize both men and things of Hanoverian origin, had Herschel presented to him. He was charmed with the simple yet lucid and modest account that the astronomer gave of his repeated endeavors; he caught a glimpse of the glory that such an observer might reflect on his reign; granted him a pension of three hundred guineas a year, and furnished him with a residence near Windsor Castle, first at Clay Hall and then at Slough. The anticipations of George III were completely realized. We may confidently assert, relative to the little house at Slough, that it is the place of all the world where the greatest number of astronomical discoveries have been made. The name of that village will never perish. Science will transmit it religiously to our latest posterity.

I shall avail myself of this opportunity to rectify a mistake, of which ignorance and idleness wish to make a triumphant handle, or, at all events, to wield in their cause as an irresistible justification. It has been repeated to satiety that at the time when Herschel entered on his astronomical career he knew nothing of mathematics. But I have already said that, during his residence at Bath, the organist of the Octagon Chapel had familiarized himself with the principles of geometry and algebra; and a still more positive proof of this is, that a difficult question on the vibration of strings loaded with small weights having been proposed for discussion in 1779, Herschel gave it a solution which was thought worthy to be inserted in several scientific periodicals of the year 1780.

The adventurous life of Herschel is here closed. The great astronomer will not quit his observatory any more, except to submit the sublime results of his laborious vigils to the Royal Society of London. These results are contained in his memoirs; they constitute one of the principal riches of the celebrated collection known under the title of *Philosophical Transactions*.

Herschel was even elected as a member of the principal academies of Europe, and about 1816 he was named a Knight of the Guelphic Order of Hanover. According to the English custom, from the time of that

nomination the title of Sir William took the place, on all his memoirs, already honored with so much celebrity, of the former appellation of Doctor William. He had been named a doctor of laws in the University of Oxford in 1786. This dignity, by special favor, was conferred on him without any of the obligatory formalities of examination, disputation, or pecuniary contribution, usual in that learned corporation.

I should wound the elevated sentiments that Herschel professed all his life, if I were not here to mention two indefatigable assistants that this fortunate astronomer found in his own family. The one was Alexander Herschel, endowed with a remarkable talent for mechanism, always at his brother's service, and who enabled him to realize without delay any ideas that he had conceived;* the other was Miss Caroline Herschel, who deserves a still more particular and detailed mention.

Miss Caroline Lucretia Herschel went to England as soon as her brother became special astronomer to the King. She received the appellation there of Assistant Astronomer, with a moderate salary. From that moment she unreservedly devoted herself to the service of her brother, happy in contributing night and day to his rapidly increasing scientific reputation. Miss Caroline shared in all the night-watches of her brother, with her eye constantly on the clock, and the pencil in her hand; she, without exception, recorded all the observations; she afterward made three or four copies in separate registers; coördinated, classed, and analyzed them. If the scientific world saw with astonishment how Herschel's works succeeded each other with unexampled rapidity during so many years, they were specially indebted for it to the ardor of Miss Caroline. Astronomy, moreover, has been directly enriched with several comets by this excellent and respectable lady. After the death of her illustrious brother, she retired to Hanover, to the house of Jahn Dietrich Herschel, a musician of high reputation, and the only surviving brother of the astronomer.

William Herschel died without pain on the 23d of August, 1822, aged eighty-three. Neither fame nor fortune ever changed in him the fund of infantine candor, inexhaustible benevolence, and sweetness of character with which nature had endowed him. He preserved to the last both his brightness of mind and vigor of intellect. For some years before his death he enjoyed with delight the distinguished success of his only son,† Sir John Herschel. At his last hour he sunk to rest with the pleasing conviction that his beloved son, heir of a great name, would not allow it to fall into oblivion, but would adorn it with fresh luster,

* When age and infirmities obliged Alexander Herschel to give up his profession as a musician, he quitted Bath and returned to Hanover, very generously provided by Sir William with a comfortable independence for life.

† Sir W. Herschel had married Mary, the widow of John Pitt, esq., possessed of a considerable jointure, and the union proved a remarkable accession of domestic happiness. This lady survived Sir William by several years. They had but this son.—TRANSLATOR'S NOTE.

and that great discoveries would also honor his career. No prediction of the illustrious astronomer has been more completely verified.

In the English journals an account is given of the interesting means adopted by the family of Sir William Herschel for preserving the remains of the great telescope of thirty-nine feet focus, constructed by that celebrated astronomer.

The metal tube of the instrument, carrying at one end the recently cleaned mirror of four feet ten inches in diameter, has been placed horizontally in the meridian on solid piers of masonry, in the midst of the circle where formerly stood the mechanism requisite for maneuvering the telescope. The 1st of January, 1840, Sir John Herschel, his wife, their children, seven in number, and some old family-servants assembled at Slough. Exactly at noon the party walked several times in procession around the instrument; they then entered the tube of the telescope, seated themselves on benches that had been prepared for the purpose, and sung a requiem, with English words, composed by Sir John Herschel himself. After their exit, the illustrious family ranged themselves around the great tube, the opening of which was then hermetically sealed. The day concluded with a party of intimate friends.

I know not whether those persons who can only appreciate things from the peculiar point of view from which they have been accustomed to look, may think there was something strange in several of the details of the ceremony that I have just described. I affirm, however, that the whole world will applaud the pious feeling which actuated Sir John Herschel, and that all the friends of science will thank him for having consecrated the humble garden where his father achieved such immortal labors by a monument more expressive in its simplicity than pyramids or statues.

CHRONOLOGICAL TABLE OF THE MEMOIRS OF WILLIAM HERSCHEL.*

1780. *Philosophical Transactions*, vol. lxx.—Astronomical observations on the periodical star in the neck of the Whale.—Astronomical observations relative to the lunar mountains.

1781. *Phil. Trans.*, vol. lxxi.—Astronomical observations on the rotation of the planets on their axes, made with a view to decide whether the daily rotation of the earth be always the same.—On the comet of 1781, afterward called the *Georgium Sidus.*

1782. *Phil. Trans.*, vol. lxxii.—On the parallax of the fixed stars.—Catalogue of double stars.—Description of a lamp micrometer, and the method of using it.—Answers to the doubts that might be raised to the high magnifying powers used by Herschel.

1783. *Phil. Trans.*, vol. lxxiii.—Letter to Sir Joseph Banks on the name to be given to the new planet.—On the diameter of the Georgium Sidus, followed by the description of a micrometer with luminous or dark disks.—On the proper motion of the solar system, and the various changes that have occurred among the fixed stars since the time of Flamsteed.

1784. *Phil. Trans.*, vol. lxxiv.—On some remarkable appearances in the polar regions of Mars, the inclination of its axis, the position of its poles, and its spheroidal form.—

* These titles are copied direct from the Philosophical Transactions, instead of being re-translated.—Translator's Note.

Some details on the real diameter of Mars, and on its atmosphere.—Analysis of some observations on the constitution of the heavens.

1785. *Phil. Trans.*, vol. lxxv.—Catalogue of double stars.—On the constitution of the heavens.

1786. *Phil. Trans.*, vol. lxxvi.—Catalogue of a thousand nebulæ and clusters of stars.—Researches on the cause of a defect of definition in vision, which has been attributed to the smallness of the optic pencils.

1787. *Phil. Trans.*, vol. lxxvii.—Remarks on the new comet.—Discovery of two satellites revolving round George's Planet.—On th ree volcanoes in the moon.

1788. *Phil. Trans.*, vol. lxxviii.—On George's Planet (Uranus) and its satellites.

1789. *Phil. Trans.*, vol. lxxix.—Observations on a comet.—Catalogue of a second thousand new nebulæ and clusters of stars.—Some preliminary remarks on the constitution of the heavens.

1790. *Phil. Trans.*, vol. lxxx.—Discovery of Saturn's sixth and seventh satellites; with remarks on the constitution of the ring, on the planet's rotation round an axis, on its spheroidal form, and on its atmosphere.—On Saturn's satellites, and the rotation of the ring round an axis.

1791. *Phil. Trans.*, vol. lxxxi.—On the nebulous stars and the suitableness of this epithet.

1792. *Phil. Trans.*, vol. lxxxii.—On Saturn's ring, and the rotation of the planet's fifth satellite round an axis.—Mixed observations.

1793. *Phil. Trans.*, vol. lxxxiii.—Observations on the planet Venus.

1794. *Phil. Trans.*, vol. lxxxiv.—Observations on a quintuple band in Saturn.—On some peculiarities observed during the last solar eclipse.—On Saturn's rotation round an axis.

1795.—*Phil. Trans.*, vol. lxxxv.—On the nature and physical constitution of the sun and stars.—Description of a reflecting telescope forty feet in length.

1796. *Phil. Trans.*, vol. lxxxvi.—Method of observing the changes that happen to the fixed stars; remarks on the stability of our sun's light.—Catalogue of comparative brightness, to determine the permanency of the luster of stars.—On the periodical star *α* Herculis, with remarks tending to establish the rotatory motion of the stars on their axes; to which is added a second catalogue of the brightness of the stars.

1797. *Phil. Trans.*, vol. lxxxvii.—A third catalogue of the comparative brightness of the stars; with an introductory account of an index to Mr. Flamsteed's observations of the fixed stars, contained in the second volume of the Historia Cœlestis, to which are added several useful results derived from that index.—Observations of the changeable brightness of the satellites of Jupiter, and of the variation in their apparent magnitudes; with a determination of the time of their rotary motions on their axes, to which is added a measure of the diameter of the second satellite, and an estimate of the comparative size of the fourth.

1798. *Phil. Trans.*, vol. lxxxviii.—On the discovery of four additional satellites of the Georgium Sidus. The retrograde motion of its satellites announced; and the cause of their disappearance at certain distances from the planet explained.

1799. *Phil. Trans.*, vol. lxxxix.—A fourth catalogue of the comparative brightness of the stars.

1800. *Phil. Trans.*, vol. xc.—On the power of penetrating into space by telescopes, with a comparative determination of the extent of that power in natural vision, and in telescopes of various sizes and construction; illustrated by select observations.—Investigation of the powers of the prismatic colors to heat and illuminate objects; with remarks that prove the different refrangibility of radiant heat; to which is added an inquiry into the method of viewing the sun advantageously with telescopes of large apertures and high magnifying powers.—Experiments on the refrangibility of the invisible rays of the sun.—Experiments on the solar and on the terrestrial rays that occasion heat; with a comparative view of the laws to which light and heat, or rather the rays which occasion them, are subject, in order to determine whether they are the same or different.

1801. *Phil. Trans.*, vol. xci.—Observations tending to investigate the nature of the sun, in order to find the causes or symptoms of its variable emission of light and heat; with remarks on the use that may possibly be drawn from solar observations.—Additional observations tending to investigate the symptoms of the variable emission of the light and heat of the sun; with trials to set aside darkening glasses, by transmitting the solar rays through liquids, and a few remarks to remove objections that might be made against some of the arguments contained in the former paper.

1802. *Phil. Trans.*, vol. xcii.—Observations on the two lately discovered celestial bodies, (Ceres and Pallas.)—Catalogue of 500 new nebulæ and clusters of stars, with remarks on the construction of the heavens.

1803. *Phil. Trans.*, vol. xciii.—Observations of the transit of Mercury over the disk of the sun; to which is added an investigation of the causes which often prevent the proper action of mirrors.—Account of the changes that have happened during the last wenty-five years in the relative situation of double stars; with an investigation of the cause to which they are owing.

1804. *Phil. Trans.*, vol. xciv.—Continuation of an account of the changes that have happened in the relative situation of double stars.

1805. *Phil. Trans.*, vol. xcv.—Experiments for ascertaining how far telescopes will enable us to determine very small angles, and to distinguish the real from the spurious diameters of celestial and terrestrial objects; with an application of the result of these experiments to a series of observations on the nature and magnitude of Mr. Harding's lately discovered star.—On the direction and velocity of the motion of the sun and solar system.—Observation on the singular figure of the planet Saturn.

1806. *Phil. Trans.*, vol. xcvi.—On the quantity and velocity of the solar motion.—Observations on the figure, the climate, and the atmosphere of Saturn and its ring.

1807. *Phil. Trans.*, vol. xcvii.—Experiments for investigating the cause of the colored concentric rings discovered by Sir Isaac Newton between two object-glasses laid one upon another.—Observations on the nature of the new celestial body discovered by Dr. Olbers, and of the comet which was expected to appear last January, in its return from the sun.

1808. *Phil. Trans.*, vol. xcviii.—Observations of a comet, made with a view to investigate its magnitude and the nature of its illumination. To which is added an account of a new irregularity lately perceived in the apparent figure of the planet Saturn.

1809. *Phil. Trans.*, vol. xcix.—Continuation of experiments for investigating the cause of colored concentric rings and other appearances of a similar nature.

1810. *Phil. Trans.*, vol. c.—Supplement to the first and second part of the paper of experiments for investigating the cause of colored concentric rings between object-glasses, and other appearances of a similar nature.

1811. *Phil. Trans.*, vol. ci.—Astronomical observations relating to the construction of the heavens, arranged for the purpose of a critical examination, the result of which appears to throw some new light upon the organization of the celestial bodies.

1812. *Phil. Trans.*, vol. cii.—Observations of a comet, with remarks on the construction of its different parts.—Observations of a second comet, with remarks on its construction.

1814. *Phil. Trans.*, vol. civ.—Astronomical observations relating to the sidereal part of the heavens, and its connection with the nebulous part; arranged for the purpose of a critical examination.

1815. *Phil. Trans.*, vol. cv.—A series of observations of the satellites of the Georgian Planet, including a passage through the node of their orbits; with an introductory account of the telescopic apparatus that has been used on this occasion, and a final exposition of some calculated particulars deduced from the observations.

1817. *Phil. Trans.*, vol. cvii.—Astronomical observations and experiments tending to investigate the local arrangement of the celestial bodies in space, and to determine the extent and condition of the Milky Way.

1818. *Phil. Trans.*, vol. cviii.—Astronomical observations and experiments selected

for the purpose of ascertaining the relative distances of clusters of stars, and of investigating how far the power of telescopes may be expected to reach into space, when directed to ambiguous celestial objects.

1822. *Memoirs of the Astronomical Society of London.*—On the positions of 145 new double stars.

The chronological and detailed analysis of so many labors would involve numerous repetitions. A systematic order will be preferable, since it more distinctly fixes the eminent place that Herschel will never cease to occupy in the small group of contemporary men of genius, while his name will reëcho to the most distant posterity. The variety and splendor of Herschel's labors vie with their extent. The more we study them the more we must admire them. It is with great men as it is with great movements in the arts: we cannot understand them without studying them from various points of view.

Let us here again make a general reflection. The memoirs of Herschel are, for the greater part, pure and simple extracts from his inexhaustible journals of observations at Slough, accompanied by brief remarks. Such a table would not suit historical details. In these respects the author has left almost everything to his biographers to do for him. And they must impose on themselves the task of assigning to the great astronomer's predecessors the portion that legitimately belongs to them out of the mass of discoveries which the public, we must say, are in the habit of erroneously referring too exclusively to Herschel.

At one time I thought of adding a note to the analysis of each of the illustrious observer's memoirs, containing a detailed account of the improvements or corrections to which the progressive march of science has led. But in order to avoid an exorbitant length in this biography, I have been obliged to give up my project. In general, I shall content myself with pointing out what belongs to Herschel, referring to Arago's Treatise on Popular Astronomy for the historical details. The life of Herschel had the rare advantage of forming an epoch in an extensive branch of astronomy; it would require us almost to write a special treatise on astronomy to show thoroughly the importance of all the researches that are due to him.

IMPROVEMENTS IN THE MEANS OF OBSERVATION.

The improvements that Herschel made in the construction and management of telescopes have contributed so directly to the discoveries with which that observer enriched astronomy that we cannot hesitate to bring them forward at once.

I find the following passage in a memoir by Lalande, printed in 1783, and forming part of the preface to Volume VIII of the Ephemerides of the Celestial Motions:

"Each time that Herschel undertakes to polish a mirror (of a telescope) he condemns himself to ten, or twelve, or even fourteen hours of constant work. He does not quit his workshop for a minute, not even to

eat, but receives from the hands of his sister that nourishment without which one could not undergo such prolonged fatigue. Nothing could induce Herschel to leave his work; for, according to him, if he did so it would be to spoil it."

The advantages that Herschel found in 1783, 1784, and 1785, in employing telescopes of twenty feet and with large apertures, made him desire to construct one much larger still. The expense would be considerable; the King provided for it. The work, begun about the close of 1785, was finished in August, 1789. This instrument had an iron cylindrical tube, thirty-nine feet four inches in length, and four feet ten inches in diameter. Such dimensions are enormous as compared with those of telescopes previously made. They will appear but small, however, to persons who have heard the report of a pretended ball given in the Slough telescope. The propagators of this popular rumor must have confounded the astronomer Herschel with the brewer Meux, and a cylinder in which a man of the smallest stature could scarcely stand upright, with divers wooden vats, as large as a house, in which beer is made in London.

Herschel's telescope, forty English feet* in length, allowed the realization of an idea, the advantages of which would not be sufficiently appreciated if I did not here recall to mind some facts.

In any telescope, whether refracting or reflecting, there are two principal parts: the part that forms the aerial images of the distant objects, and the small lens by the aid of which these images are magnified just as if they consisted of radiating matter. When the image is produced by means of a lenticular glass, the place it occupies will be found in the prolongation of the line that extends from the object to the center of the lens. The astronomer, furnished with an eye-piece and wishing to examine that image, must necessarily place himself *beyond* the point where the rays that form it have crossed each other; *beyond*, let us carefully remark, means *farther off* from the object-glass. The observer's head, cannot then interfere with the formation or the brightness of the image, however small may be the distance from which he may have to study it. But it is no longer thus with the image formed by means of reflection. For the image is now placed between the object and the reflecting mirror, and when the astronomer approaches in order to examine it, he inevitably intercepts, if not the totality, at least a very considerable portion, of the luminous rays, which would otherwise have contributed to give it great distinctness. It will now be understood why, in optical instruments where the images of distant objects are formed by the reflection of light, it has been necessary to carry the images, by the aid of a second reflection, out of the tube that contains and sustains the

* Conforming to general usage, and to Sir W. Herschel himself, we shall allude to this instrument as the *forty-foot* telescope, though M. Arago adheres to thirty-nine feet and drops the inches, probably because the Parisian foot is rather longer than the English.—TRANSLATOR'S NOTE.

principal mirror. When the small mirror on the surface of which the second reflection is effected is plane and inclined at an angle of 45° to the axis of the telescope; when the image is reflected laterally through an opening made near the edge of the tube and furnished with an eye-piece; when, in a word, the astronomer looks definitively in a direction perpendicular to the line described by the luminous rays coming from the object and falling on the center of the great mirror, then the telescope is called *Newtonian*. But in the *Gregorian* telescope the image formed by the principal mirror falls on a second mirror, which is very small, slightly curved, and parallel to the first. The small mirror reflects the first image and throws it beyond the large mirror, through an opening made in the middle of that mirror.

Both in the one and in the other of these two telescopes, the small mirror interposed between the object and the great mirror forms relative to the latter a sort of screen which prevents its entire surface from contributing toward forming the image. The small mirror also, in regard to intensity, gives some trouble.

Let us suppose, in order to clear up our ideas, that the material of which the two mirrors are made reflects only half of the incident light. In the course of the first reflection, the immense number of rays that the aperture of the telescope had received may be considered as reduced to half. Nor is the diminution less on the small mirror. Now, half of a half is a quarter. Therefore the instrument will send to the eye of the observer only a quarter of the incident light that its aperture had received If these two causes of diminished light did not exist in a refracting telescope, it would give, under parity of dimensions, four times more * light than a Newtonian or Gregorian telescope gives.

Herschel did away with the small mirror in his large telescope by placing the large mirror obliquely in the tube which causes the images to be formed, not in the axis of the tube, but very near the circumference or edge of the outer mouth, as we may call it. The observer might therefore look at them directly merely by means of an eye-glass. A small portion of the astronomer's head, it is true, encroaches on the tube, forms a screen, and interrupts some incident rays. Still, in a large telescope, this loss does not amount to half as much as it would inevitably do if the small mirror were there.

Those telescopes in which the observer, standing at the anterior extremity of the tube, looks directly into it, turning his back to the objects, were called by Herschel *front-view telescopes*. In Volume LXXVI of the Philosophical Transactions, he says that the idea of this construction occurred to him in 1776, and that he then applied it unsuccessfully to a ten-foot telescope; that during the year 1784 he again made a fruitless trial of it in a twenty-foot telescope. Yet I find that on the 7th of September, 1784, he recurred to *a front view* in observing some nebulæ and groups of stars. However discordant these dates may be, we cannot

* It would be more correct to say four times *as much* light.—TRANSLATOR.

without injustice neglect to remark that a front-view telescope was already described in 1732, in Volume VI of the collection entitled "Machines and Inventions approved by the Academy of Sciences." The author of this innovation is Jacques Lemaire, who has been unduly confounded with the English Jesuit, Christopher Maire, assistant to Boscovitch, in measuring the meridian comprised between Rome and Rimini. Jacques Lemaire, having only telescopes of moderate dimensions in view, was obliged, in order not to sacrifice any of the light, to place the great mirror so obliquely that the image formed by its surface should fall entirely outside the tube of the instrument. So great a degree of inclination would certainly distort the image. The *front-view* construction is admissible only in very large telescopes.

I find in the Transactions for 1803 that, in solar observations, Herschel sometimes employed telescopes, the great mirror of which was made of glass. It was with a telescope of this kind, seven feet long, and six inches and three-tenths in diameter, that he observed the transit of Mercury on the 9th of November, 1802.

Practical astronomers know how much the mounting of a telescope contributes to produce correct observations. The difficulty of a solid yet very movable mounting increases rapidly with the dimensions and weight of an instrument. We may then conceive that Herschel had to surmount many obstacles in mounting a telescope suitably of which the mirror alone weighed upward of 1,000 kilograms, (a ton.) But he solved this problem to his entire satisfaction by the aid of a combination of spars, pulleys, and ropes, of which a correct idea may be formed by referring to the wood-cut given in Arago's Treatise on Popular Astronomy, (Vol. I.) This apparatus, and the different stands that Herschel devised for telescopes of smaller dimensions, assign to that llustrious observer a distinguished place among the most ingenious mechanics of our age.

The public in general—I may even say the greater part of astronomers—know not what was the effect that the great forty-foot telescope had in the labors and discoveries of Herschel. Still, we are not less mistaken when we suppose that the observer of Slough always used this telescope than in imagining, with Baron von Zach, (see *Monatliche Correspondenz*, January, 1802) that the colossal instrument was of no use at all; that it did not contribute to any new discovery; that it must be considered as a mere object of curiosity. These assertions are distinctly contradicted by Herschel's own words. In the volume of Philosophical Transactions for the year 1795 (p. 350) I read, for example: "On the 28th of August, 1789, having directed my telescope (of forty feet) to the heavens, I discovered the sixth satellite of Saturn, and I perceived the spots on that planet better than I had been able to do before." (See also relative to this sixth satellite the Philosophical Transactions for 1790, p. 10.) In that same volume of 1790 (p. 11) I find: "The great light of my forty-foot telescope was so useful that on the 17th of September, 1789, I re-

marked the seventh satellite, then situated at its greatest western elongation."

The 10th of October, 1791, Herschel saw the ring of Saturn and the fourth satellite, looking in at the mirror of his forty-foot telescope, with his naked eye, without any kind of eye-piece.

Let us acknowledge the true motives that prevented Herschel from oftener using his forty-foot telescope. Notwithstanding the excellence of the mechanism, the maneuvering of that instrument required the constant aid of two laborers, and that of another person charged with noting the time at the clock. Besides this, during nights when the variation of temperature was considerable, this telescope, on account of its great mass, was always behind the atmosphere in thermometric changes, giving rise to a difference of density in the air within and without the tube very injurious to the distinctness of the images.

Herschel found that in England there are not above a hundred hours in a year during which the heavens can be advantageously observed with a telescope of forty feet, furnished with a magnifying power of a thousand. This remark led the celebrated astronomer to the conclusion that to take a complete survey of the heavens with his large instrument, though each successive field should remain only for an instant under inspection, would not require less than eight hundred years.

He explains very clearly the rare occurrence of the circumstances in which it is possible to make good use of a telescope of forty feet, and of very large aperture.

A telescope does not magnify real objects only, but magnifies also the apparent irregularities arising from atmospheric refractions; now, all other things being equal, these irregularities of refraction must be so much the greater, so much the more frequent, as the stratum of air is thicker through which the rays have passed in going to form the image.

Astronomers expressed extreme surprise when, in 1782, they learned that Herschel had applied linear magnifying powers of a thousand, of twelve hundred, of two thousand two hundred, of two thousand six hundred, and even of six thousand times, to a reflecting telescope of seven feet in length. The Royal Society of London participated in this surprise, and officially requested Herschel to give publicity to the means he had adopted for using such amounts of magnifying power in his telescopes. Such was the object of a memoir that he inserted in Volume LXXII of the Philosophical Transactions; and it dissipated all doubts. No one will be surprised that magnifying powers, which it would seem ought to have shown the lunar mountains as the chain of Mont Blanc is seen from Maçon, from Lyons, and even from Geneva, were not easily believed in. They did not know that Herschel had never used magnifying powers of three thousand and six thousand times, except in observing brilliant stars; they had not remembered that light reflected by planetary bodies is too feeble to continue distinct

under the same degree of magnifying power as the direct light of the fixed stars does.

Opticians had given up, more from theory than from careful experiments, attempting high magnifying powers, even for reflecting telescopes. They thought that the image of a small circle cannot be distinct, cannot be sharp at the edges, unless the pencil of rays coming from the object in nearly parallel lines, and which enters the eye after having passed through the eye-piece, be sufficiently broad. This being once granted, the inference followed that an image ceases to be well defined when it does not strike at least two of the nervous filaments of the retina with which that organ is supposed to be overspread. These gratuitous conditions, grafted on each other, vanished in presence of Herschel's observations. After having put himself on his guard against the effects of diffraction—that is to say, against the scattering that light undergoes when it passes the terminal angles of bodies—the illustrious astronomer proved, in 1786, that objects can be seen well defined by means of pencils of light whose diameter does not equal five-tenths of a millimeter.

Herschel considered the almost unanimous opinion of the double-lens eye-piece being preferable to the single-lens eye-piece as a very injurious prejudice to science, since experience proved to him, notwithstanding all theoretic deductions, that, with equal magnifying powers, in reflecting telescopes, at least (and this restriction is of some consequence), the images were brighter and better defined with single than with double eye-pieces. On one occasion this latter eye-piece could not show him the bands of Saturn, while by the aid of a single lens they were perfectly visible. Herschel said: "The double eye-piece must be left to amateurs, and to those who, for some particular object, require a large field of vision." (Philosophical Transactions, 1782, pp. 94 and 95.)

It is not only relative to the comparative merit of single or double eye-pieces that Herschel differs in opinion from opticians generally. He thinks, moreover, that he has proved, by decisive experiments, that concave eye-pieces (like that used by Galileo) surpass the convex eye-piece, both as regards clearness and definition.

Herschel assigns the date of 1776 to the experiments which he made to decide this question. (Philosophical Transactions, year 1815, p. 297.) Plano-concave and double-concave lenses produced similar effects. In what did these lenses differ from the double-convex lenses? In one particular only: the latter received the rays reflected by the large mirror of the telescope after their union at the focus, whereas the concave lenses received the same rays before that union. When the observer made use of a convex lens, the rays that went to the back of the eye to form an image on the retina had previously crossed each other in the air, but no crossing of this kind took place when the observer used a concave lens. Holding the double advantage of this latter sort of lens over the other as quite proved, one would be inclined, like Herschel,

to admit "that a certain mechanical effect, injurious to clearness and definition, would accompany the focal crossing of the rays of light."*

This idea of the crossing of the rays suggested an experiment, the result of which deserves to be recorded. A telescope of ten English feet was directed toward an advertisement covered with very small printing, and placed at a sufficient distance. The convex lens of the eye-piece was carried, not by a tube, properly so called, but by four fine rigid wires, placed at right angles; this arrangement left the focus open in almost every direction. A concave mirror was then placed so that it threw a very condensed image of the sun laterally on the very spot where the image of the advertisement was formed. The solar rays, after having crossed each other, finding nothing on their route, went on and lost themselves in space. A screen, however, allowed the rays to be intercepted at will before they united. This done, having applied the eye to the eye-piece, and directed all his attention to the telescopic image of the advertisement, Herschel did not perceive that the taking away and then replacing the screen made the least change in the brightness or definition of the letters. It was, therefore, of no consequence, in this instance as well as in the other, whether the immense quantity of solar rays crossed each other at the very place where, *in another direction*, the rays united that formed the image of the letters. I have marked in Italics the words that especially show in what this curious experiment differs from the previous experiments, and yet does not entirely contradict them. In this instance, the rays were of different origin, those coming from the advertisement and those from the sun crossed each other, respectively, in an almost rectangular direction; while in the comparative examination of the stars with convex and with concave eye-pieces, the rays that seemed to have a mutual influence had a common origin, and crossed each other at very acute angles. There seems to be nothing, then, in the results at which we need to be much surprised.

Herschel increased the catalogue, already so extensive, of the mysteries of vision, when he explained in what manner we must endeavor to distinguish separately the two members of certain double stars very close to each other. He said, "If you wish to assure yourself that η Coronæ is a double star, first direct your telescope to α Geminorum, to ζ Aquarii, to μ Draconis, to ρ Herculis, to α Piscium, to ε Lyræ. Look at those stars for a long time, so as to acquire the habit of observing such objects; then pass on to ξ Ursæ majoris, where the closeness of the two members is still greater. In a third essay select ι Bootis,

* On comparing the Cassegrain telescopes, with a small convex mirror, to the Gregorian telescopes, with a small concave mirror, Captain Kater found that the former, in which the luminous rays do not cross each other before falling on the small mirror, possess, as to intensity, a marked advantage over the latter, in which this crossing takes place.

(marked 44 by Flamsteed and i in Harris's maps,)* the star that precedes α Orionis n of the same constellation, and you will then be prepared for the more difficult observation of η Coronæ. Indeed, η Coronæ is a sort of miniature of i Bootis, which may itself be considered as a miniature of α Geminorum." (Philosophical Transactions, 1782, p. 100.)

As soon as Piazzi, Olbers, and Harding had discovered three of the numerous telescopic planets now known, Herschel proposed to himself to determine their real magnitudes; but telescopes not having then been applied to the measurement of excessively small angles, it became requisite, in order to avoid any illusion, to try some experiments adapted to giving a scale of the powers of those instruments. Of the labor of our indefatigable astronomer in this line, I am going to give a condensed account.

The author relates first, that in 1774 he endeavored to ascertain experimentally, with the naked eye, and at the distance of distinct vision, what angle a circle must subtend to be distinguished by its form from a square of similar dimensions. The angle was never smaller than 2′ 17″; therefore, at its maximum it was about one-fourteenth of the angle subtended by the diameter of the moon.

Herschel did not say of what nature the circles and squares of paper were that he used, nor on what background they were projected. It is an omission to be regretted, since in those phenomena the intensity of light must be an important feature. However it may have been, the scrupulous observer, not daring to extend to telescopic vision what he had discovered relative to vision with the naked eye, he undertook to do away with all doubt by direct observations.

On examining some heads of pins, placed at a distance in the open air, with a three-foot telescope, Herschel could easily discern that those bodies were round when the subtended angles became, after being magnified, 2′ 19″. This is almost exactly the result obtained with the naked eye.

When the globules were darker—when, instead of pins' heads, small globules of sealing-wax were used—their spherical form did not begin to be distinctly visible till the moment when the subtended magnified angles—that is, the moment when the natural angle multiplied by the magnifying power—amounted to five minutes.

In a subsequent series of experiments, some globules of silver, placed very far from the observer, allowed their globular form to be perceived, even when the magnified angle remained below two minutes.

* In the selection of i Bootis as a test, Arago has taken the precaution of giving its corresponding denomination in other catalogues, and Bailey appends the following note, No. 2032, to 44 Bootis: "In the British Catalogue this star is not denoted by any letter, but Bayer calls it i, and on referring to the earliest MS. catalogue in MSS. Vol. XXV, I find it is there so designated; I have therefore restored the letter." (See Bailey's edition of Flamsteed's British Catalogue of Stars, 1835.) The distance between the two members of this double star is 3″.7, and position 23°.5. (See Bedford Cycle.)—TRANSLATOR.

Under equality of subtended angle, then, the telescopic vision with strong magnifying powers showed itself superior to the naked-eye vision. This result is not unimportant.

If we take notice of the magnifying powers used by Herschel in these laborious researches—powers that often exceeded five hundred times—it will appear to be established that the telescopes possessed by modern astronomers may serve to verify the round form of distant objects, the form of celestial bodies, even when the diameters of those bodies do not subtend naturally, to the naked eye, angles of above three-tenths of a second; and 500 multiplied by three-tenths of a second give 2′ 30″.

Much still remained to be learned in regard to refracting telescopes; even when they already served to reveal brilliant astronomical phenomena; the result was due rather to chance than to definite theory. Their theory, as far as it depended on geometry and optics, had made rapid progress. These two early phases of the problem leave but little more to be wished for; it is not so with a third phase, hitherto a good deal neglected, connected with physiology, and with the action of light on the nervous system. Therefore, we should search in vain in old treatises on optics and on astronomy for a strict and complete discussion on the comparative effect that the size and intensity of the images that the magnifying power and the aperture of a telescope may have, by night and by day, on the visibility of the faintest stars. This lacuna Herschel tried to fill up in 1799; such was the aim of the memoir entitled "On the Space-penetrating Power of Telescopes."

This memoir contains excellent things; still it is far from exhausting the subject. The author, for instance, entirely overlooks the observations made by day. I also find that the hypothetical part of the discussion is not perhaps as distinctly separated from the rigorous part as it might be; that doubtful numbers, though given with a degree of precision down to the smallest decimals, do not contrast well as terms of comparison with those which, on the contrary, rest on observations bearing mathematical evidence of correctness.

Whatever may be thought of these remarks, the astronomer or the physicist who would like again to undertake the question of visibility with telescopes will find some important facts in Herschel's memoir, and some ingenious observations, well adapted to serve them as guides.

LABORS IN SIDEREAL ASTRONOMY.

The curious phenomenon of a periodical change of intensity in certain stars very early excited the earnest attention of Herschel. The first memoir by that illustrious observer, presented to the Royal Society of London, and inserted in the Philosophical Transactions, treats especially of the changes of intensity of the star *o* in the neck of the Whale.

This memoir was dated from Bath, May, 1780. Eleven years afterward, in the month of December, 1791, Herschel communicated a second time to that celebrated English society the observations that he had made by

occasionally directing his telescopes to this mysterious star. At both those epochs the observer's attention was chiefly directed to the absolute values of the *maxima* and *minima* of intensity.

The changeable star in the Whale was not the only periodical star with which Herschel occupied himself. His observations of 1795 and of 1796 proved that α Herculis also belongs to the category of variable stars, and that the time requisite for the accomplishment of all the changes of intensity, and for the star's return to any given state, was sixty days and a quarter. When Herschel obtained this result, about ten changeable stars were already known; but they were all either of very long or very short periods. The illustrious astronomer considered that by introducing between two groups that exhibited very short and very long periods a star of somewhat intermediate conditions—for instance, one requiring sixty days to accomplish all its variations of intensity—he had advanced the theory of these phenomena by an essential step; the theory at least that attributes all to a movement of rotation which the stars may undergo round their centers.

Sir William Herschel's catalogues of double stars offer a considerable number to which he ascribes a decided green or blue tint. In binary combinations, when the small star appears very blue or very green, the large one is usually yellow or red. It does not appear that the great astronomer took sufficient interest in this circumstance. I do not find, indeed, that the almost constant association of two complementary colors (of yellow and blue, or of red and green) ever led him to suspect that one of those colors might not have anything real in it, that it often might be a mere illusion, a mere result of contrast. It was only in 1825 that I showed that there are stars whose contrast really explains their apparent color; but I have proved besides that blue is incontestably the color of certain insulated stars, or stars that have only white ones, or other blue ones, in their vicinity. Red is the only color that the ancients ever distinguished from white in their catalogues.

Herschel also endeavored to introduce numbers in the classification of stars as to magnitude; he has endeavored, by means of these, to show the comparative intensity of a star of the first magnitude with one of second, or one of third magnitude, &c.

In one of the earliest of Herschel's memoirs, we find that the apparent sidereal diameters are proved to be for the greater part factitious, even when the best telescopes are used. Diameters estimated by seconds—that is to say, reduced according to the magnifying power—diminish in certainty as the magnifying power is increased. These results are of the greatest importance.

In the course of his investigation of sidereal parallax, though without finding it, Herschel made an important discovery—that of the proper motion of our system. To show distinctly the direction of the motion of the solar system, not only was a displacement of the sidereal perspective required, but profound mathematical knowledge, and a peculiar tact.

This peculiar tact Herschel possessed in an eminent degree. Moreover, the result deduced from the very small number of proper motions known at the beginning of 1783, has been found almost to agree with that found recently by our best astronomers, with the application of subtile analytical formulæ, to a considerable number of exact observations.

The proper motions of the stars have been known for more than a century, and even Fontenelle used to say, in 1738, that the sun has probably a similar motion. The idea of partly attributing the displacement of the stars to a motion of the sun had suggested itself to Bradley and to Mayer. Lambert especially had been very explicit on the subject. Until then, however, there were only conjectures and mere probabilities. Herschel passed these limits. He proved that the sun himself positively moves, and that in this respect that immense and dazzling body must also be classed among the stars; that the apparently inextricable irregularities of numerous sidereal proper motions arise in great measure from the displacement of the solar system; that, in short, the point of space toward which we are annually advancing is situated in the constellation of Hercules.

These are magnificent results. The discovery of the proper motion of our system will always be accounted among Herschel's highest claims to glory, even after the mention that my duty as historian has obliged me to make of the anterior conjectures of Fontenelle, of Bradley, of Mayer, and of Lambert.

By the side of this great discovery we should place another, that seems likely to be expanded in future. The results which it allows us to hope for will be of extreme importance. The discovery here alluded to was announced to the learned world in 1803; it is that of the reciprocal dependence of several stars, connected the one with the other, as the several planets and their satellites of our system are with the sun.

Let us to these immortal labors add the ingenious ideas that we owe to Herschel on the nebulæ, on the constitution of the Milky Way, on the universe as a whole—ideas which almost by themselves constitute the actual history of the formation of the worlds—and we cannot have too deep a reverence for that powerful genius that notwithstanding the play of an ardent imagination scarcely ever erred.

LABORS RELATIVE TO THE SOLAR SYSTEM.

Herschel devoted much time to the sun, but only relative to its physical constitution. The observations that he made on this subject, and the consequences that he deduced from them, equal in interest the most ingenious discoveries for which the sciences are indebted to him.

In his important memoir in 1795, the great astronomer declares himself convinced that the substance by the intermediation of which the sun shines cannot be either a liquid or an elastic fluid. It must be analogous to our clouds, and float in the transparent atmosphere of that body. The sun has, according to him, two atmospheres, endowed with

motions quite independent of each other. An elastic fluid of an unknown nature is being constantly formed on the dark surface of the sun, and rising up, on account of its specific lightness, it forms the *pores* in the stratum of reflecting clouds; then, combining with other gases, it produces the striæ in the region of luminous clouds. When the ascending currents are powerful, they give rise to the *nuclei*, to *penumbræ*, and the *faculæ*. If this explanation of the formation of solar spots is well founded, we must expect to find that the sun does not constantly emit equal quantities of light and heat. Recent observations have verified this conclusion. But large nuclei, large penumbræ, striæ, faculæ, do they indicate an abundant, luminous, and calorific emission, as Herschel supposed? That would be the result of his hypothesis on the existence of very active ascending currents, but direct experience seems to contradict it.

The following is the way in which a learned physicist, Sir David Brewster, appreciates this view of Herschel's: "It is not conceivable that luminous clouds, ceding to the lightest impulses and in a state of constant change, can be the source of the sun's devouring flame and of the dazzling light which it emits; nor can we admit, besides, that the feeble barrier formed by planetary clouds would shelter the objects that it might cover from the destructive effects of the superior elements."

Sir David Brewster imagines that the non-luminous rays of caloric, which form a constituent part of the solar light, are emitted by the dark nucleus of the sun; while the visible colored rays proceed from the luminous matter by which the nucleus is surrounded. "From thence," he says, "proceeds the reason of light and heat always appearing in a state of combination; the one emanation cannot be obtained without the other. With this hypothesis we could readily explain why it is hottest when there are most spots, because the heat of the nucleus would then reach us without having been weakened by the atmosphere that it usually has to traverse." But it is far from being an ascertained fact that we experience increased heat during the apparition of solar spots; the inverse phenomenon is more probably true.

Herschel also studied the physical constitution of the moon. In 1780, he sought to measure the height of the mountains of our satellite. The conclusion that he drew from his observations was, that few of the lunar mountains exceed 800 meters, (or 2,600 feet.) More recent selenographic observations give conclusions different from this. There is reason to remark, on this occasion, how much the result presented by Herschel differs from any tendency to the extraordinary or the gigantic, that has been so unjustly assigned as the characteristic of the illustrious astronomer.

At the close of 1787, Herschel presented a memoir to the Royal Society, the title of which must have made a strong impression on the popular mind. The author therein relates that, on the 19th of April, 1787, he had observed in the non-illuminated part of the moon—that is, in

the then dark portion—three volcanoes in a state of ignition. Two of these volcanoes appeared to be on the decline, the other appeared to be active. Such was his conviction of the reality of the phenomenon, that the next morning he made the following record: "The volcano burns with more violence than last night." The real diameter of the volcanic light was 5,000 meters, (16,400 English feet.) Its intensity appeared very superior to that of the nucleus of a comet then in apparition. He further added: "The objects situated near the crater are feebly illuminated by the light that emanates from it;" and concludes thus: "In short, this eruption very much resembles the one I witnessed on the 4th of May, 1783."

How happens it, after such exact observations, that few astronomers now admit the existence of active volcanoes in the moon? I will explain this singularity in a few words.

The various parts of our satellite do not all equally reflect light. Here, it may depend on the form, elsewhere, on the nature of the materials. Those who have examined the moon with telescopes know how very considerable the difference arising from these two causes may be, how much brighter one point of the moon sometimes is than those around it. Now, it is quite evident that the relations of intensity between the faint parts and the brilliant ones must continue to exist, whatever be the origin of the illuminating light. In the portion of the lunar globe that is illuminated by the sun there are, everyone knows, some points, the brightness of which is extraordinary compared to those around them; those same points, when they are seen in that portion of the moon that is only lighted by the earth, or in the ash-colored part, will still predominate over the neighboring regions by their comparative intensity. Thus we may explain the observations of the Slough astronomer, without recurring to volcanoes. While the observer was studying in the non-illuminated portion of the moon the supposed volcano of the 20th of April, 1787, his nine-foot telescope showed him in truth, by the aid of the secondary rays proceeding from the earth, even the darkest spots.

Herschel did not recur to the discussion of the supposed actually burning lunar volcanoes until 1791. In the volume of the Philosophical Transactions for 1792, he relates that in directing a twenty-foot telescope, magnifying three hundred and sixty times, to the entirely eclipsed moon, on the 22d of October, 1790, there were visible, over the whole face of the satellite, about a hundred and fifty very luminous red points. The author declares that he will observe the greatest reserve relative to the nature of all these points, their great brightness, and their remarkable color.

Yet is not red the usual color of the moon when eclipsed, and when it has not entirely disappeared? Could the solar rays reaching our satellite by the effect of refraction, and after an absorption experienced in the lowest strata of the terrestrial atmosphere, receive any other tint? Are there not in the moon, when freely illuminated, and opposite to the

sun, from one to two hundred little points, remarkable by the brightness of their light? Would it be possible for these little points not to be also distinguishable in the moon when it receives only the portion of solar light which is refracted and colored by our atmosphere?

Herschel was more successful in his remarks on the absence of a lunar atmosphere. During the solar eclipse of the 5th September, 1793, the illustrious astronomer particularly directed his attention to the shape of the acute horn resulting from the intersection of the limbs of the moon and of the sun. He deduced from his observation that if toward the point of the horn there had been a deviation of only one second, occasioned by the refraction of the solar light in the lunar atmosphere, it would not have escaped him.

He also made the planets the object of numerous researches. Mercury was the one to which he gave least attention; he found its disk perfectly round on observing it during its projection—that is to say, in astronomical language, during its transit over the sun, on the 9th of November, 1802. He sought to determine the time of the rotation of Venus as early as 1777. He published two memoirs relative to Mars, the one in 1781, the other in 1784, and we owe to him the discovery of its being flattened at the poles. After the discovery of the small planets, Ceres, Pallas, Juno, and Vesta, by Piazzi, Olbers, and Harding, Herschel applied himself to measuring their angular diameters. He concluded from his researches that those four new bodies did not deserve the name of planets, and he proposed to call them asteroids. This epithet was subsequently adopted, though bitterly criticised by a historian of the Royal Society of London, Dr. Thomson, who went so far as to suggest that the learned astronomer "had wished to deprive the first observers of those bodies of all idea of rating themselves as high as himself in the scale of astronomical discoverers." I should require nothing further to annihilate such an imputation than to put it by the side of the following passage, extracted from a memoir by this celebrated astronomer, published in the Philosophical Transactions for the year 1805: "The specific difference existing between planets and asteroids appears now, by the addition of a third individual of the latter species, to be more completely established, and that circumstance, in my opinion, has added more to the *ornament* of our system than the discovery of a new planet could have done."

Although much has not resulted from Herschel's investigations in regard to the physical constitution of Jupiter, astronomy is indebted to him for several important results relative to the time of that planet's rotation. He also made numerous observations on the distances and comparative magnitude of its satellites.

The compression of Saturn, the duration of its rotation, the physical constitution of this planet and that of its ring, were, on the part of Herschel, the object of numerous researches which have much contributed

to the progress of planetary astronomy. But on this subject two important discoveries especially added new glory to his name.

Of the five known satellites of Saturn at the close of the seventeenth century, Huygens had discovered the fourth; Cassini the others.

The field seemed to be exhausted, when news from Slough announced that this was a mistake.

On the 28th of August, 1789, the great forty-foot telescope revealed to Herschel a satellite still nearer to the ring than the other five already observed. According to the principles of the nomenclature previously adopted, the small body of the 28th August ought to have been called the first satellite of Saturn; the numbers indicating the places of the other five would then have been each increased by a unity. But the fear of introducing confusion into science by these continual changes of denomination induced a preference for calling the new satellite the sixth.

Thanks to the prodigious powers of the forty-foot telescope, a last satellite, the seventh, showed itself on the 17th of September, 1789, between the sixth and the ring.

This seventh satellite is extremely faint. Herschel, however, succeeded in seeing it whenever circumstances were very favorable, even by the aid of the twenty-foot telescope.

The discovery of the planet Uranus, and the detection of its satellites, will always occupy one of the highest places among those by which modern astronomy is honored.

On the 13th of March, 1781, between ten and eleven o'clock at night, while Herschel was examining the small stars near H Geminorum with a seven-foot telescope, bearing a magnifying power of two hundred and twenty-seven times, one of these stars seemed to have an unusual diameter, and it was, therefore, thought to be a comet. It was under this denomination that it was discussed at the Royal Society of London. But the researches of Herschel and of Laplace showed later that the orbit of the new body was nearly circular, and Uranus was consequently elevated to the rank of a planet.

The immense distance of Uranus, its small angular diameter, and the feebleness of its light, scarcely allowed the hope that, if that body had satellites, they could be perceived from the earth. Herschel was not a man to be deterred by such discouraging conjectures. Therefore, since powerful telescopes of the ordinary construction—that is to say, with two mirrors conjugated—had not enabled him to discover anything, he substituted, in the beginning of January, 1787, *front-view* telescopes—that is, telescopes throwing much more light on the objects, the small-mirror being then suppressed, and with it one of the causes of loss of light is got rid of.

By this means, with patient labor and observations requiring a rare perseverance, Herschel made (from the 11th of January, 1787, to the 28th of February, 1794) the discovery of the six satellites of his planet, and thus completed the system of worlds that belongs entirely to himself.

There are several of Herschel's memoirs on comets. In analyzing them we shall see that this acute observer could not touch anything without making further discoveries in regard to it.

He applied some of his fine instruments to the study of the physical constitution of a comet discovered by Mr. Pigott, on the 28th September, 1807. The nucleus was round and well-determined. Some measures taken on the day when the nucleus subtended only an angle of a single second gave as its real diameter $\frac{6}{100}$ of the diameter of the earth.

Herschel saw no phase at an epoch when only $\frac{7}{10}$ of the nucleus could be illuminated by the sun. The nucleus then must shine by its own light.

This is a legitimate inference in the opinion of every one who will allow, on the one hand, that the nucleus is a solid body, and on the other, that it would have been possible to observe a phase of $\frac{8}{10}$ on a disk whose apparent total diameter did not exceed one or two seconds of a degree.

Very small stars seemed to grow much paler when they were seen through the coma or through the tail of the comet.

This faintness may have only been apparent, and might arise from the circumstance of the stars being then projected on a luminous background. Such is, indeed, the explanation adopted by Herschel. A gaseous medium, capable of reflecting sufficient solar light to efface that of some stars, would appear to him to possess in each stratum a sensible quantity of matter, and to be, for that reason, a cause of real diminution of the light transmitted, though nothing reveals the existence of such a cause.

This argument, offered by Herschel in favor of the system which transforms comets into self-luminous bodies, has not, as we may perceive, much force. I might venture to say as much of several other remarks by this great observer. He tells us that the comet was distinctly visible in the telescope on the 21st of February, 1808; now, on that day, its distance from the sun amounted to 2.7 times the mean radius of the terrestrial orbit; its distance from the observer was 2.9: "What probability would there be that rays going to such distances, from the sun to the comet, could, after their reflection, be seen by an eye nearly three times more distant from the comet than from the sun?"

It is only numerical determinations that could give value to such an argument. By satisfying himself with vague reasoning, Herschel did not even perceive that he was committing a great mistake by making the comet's distance from the observer appear to be an element of visibility. If the comet be self-luminous, its intrinsic splendor (its brightness for unity of surface) will remain constant at any distance, as long as the subtended angle remains sensible. If the body shines by borrowed light, its brightness will vary only according to its change of distance from the sun; nor will the distance of the observer occasion any change in the visibility; always, let it be understood, with the restriction that the apparent diameter shall not be diminished below certain limits.

Herschel finished his observations of a comet that was visible in January, 1807, with the following remark:

"Of the sixteen telescopic comets that I have examined, fourteen had no solid body visible at their center; the other two exhibited a central light, very ill-defined, that might be termed a nucleus, but a light that certainly could not deserve the name of a disk."

The beautiful comet of 1811 became the object of his conscientious labor. With large telescopes he saw, in the midst of the gaseous head, a reddish body of planetary appearance, which bore strong magnifying powers, and showed no sign of phase. Hence Herschel concluded that it was self-luminous. Yet if we reflect that the planetary body under consideration was not a second in diameter, the absence of a phase does not appear a conclusive argument.

The light of the head had a bluish-green tint. Was this a real tint, or did the central reddish body, only through contrast, cause the surrounding vapor to appear colored? Herschel did not examine the question from this point of view.

The head of the comet appeared to be enveloped at a certain distance, on the side toward the sun, by a brilliant narrow zone, embracing about a semicircle, and of a yellowish color. From the two extremities of the semicircle there arose, toward the region away from the sun, two long luminous streaks which limited the tail. Between the brilliant circular semi-ring and the head, the cometary substance seemed dark, very rare, and very diaphanous.

The luminous semi-ring always presented similar appearances in all the positions of the comet; it was not then possible to attribute to it really the annular form—the shape of Saturn's ring, for example. Herschel sought whether a spherical semi-envelope of luminous matter, and yet diaphanous, would not lead to a natural explanation of the phenomenon. In this hypothesis, the visual rays, which on the 6th of October, 1811, traversed a thickness of matter of about 399,000 kilometers, (248,000 English miles,) while the visual rays near the head of the comet did not meet above 80,000 kilometers (50,000 miles) of matter. As the brightness must be proportional to the quantity of matter traversed, there could not fail to be an appearance around the comet of a semi-ring five times more luminous than the central regions. This semi-ring, then, was an effect of projection, and it has revealed a circumstance to us truly remarkable in the physical constitution of comets.

The two luminous streaks that outlined the tail at its two limits may be explained in a similar manner; the tail was not flat, as it appeared to be; it had the form of a conoid, with its sides of a certain thickness. The visual lines which traversed those sides almost tangentially evidently met much more matter than the visual lines passing across. This maximum of matter could not fail of being represented by a maximum of light.

The luminous semi-ring appeared one day to be suspended in the

diaphanous atmosphere by which the head of the comet was surrounded, at a distance of 518,000 kilometers (322,000 English miles) from the nucleus.

This distance was not constant. The matter of the semi-annular envelope seemed even to be precipitated by slow degrees through the diaphanous atmosphere; finally it reached the nucleus; the earlier appearances vanished; the comet was reduced to a globular nebula.

During its period of dissolution, the ring appeared sometimes to have several branches.

The luminous shreds of the tail seemed to undergo rapid, frequent, and considerable variations of length. Herschel discerned symptoms of a movement of rotation both in the comet and in its tail. This rotatory motion carried unequal shreds from the center toward the border, and reciprocally. On looking from time to time at the same region of the tail—at the border, for example—sensible changes of length must have been perceptible, which, however, had no real existence. Herschel thought, as I have already said, that the beautiful comet of 1811 and that of 1807 were self-luminous. The second comet of 1811 appeared to him to shine only by borrowed light. It must be acknowledged that these conjectures did not rest on anything demonstrative.

In attentively comparing the comet of 1807 with the beautiful comet of 1811, relative to the changes of distance from the sun, and the modifications resulting thence, Herschel put it beyond doubt that these modifications have something individual in them, something relative to a special state of the nebulous matter. On one celestial body the changes of distance produce an enormous effect; on another the modifications are insignificant.

OPTICAL LABORS.

I shall say very little as to the discoveries that Herschel made in physics, since every one is familiar with them. They are to be found in all elementary works, and are given in verbal instruction; they must be considered as the starting-point of a multitude of important labors with which the sciences have been enriched during later years.

The chief of these is that of the dark radiating heat which is found mixed with light.

In studying the phenomena, not with the eye, as Newton did, but with a thermometer, Herschel discovered that the solar spectrum is prolonged on the red side far beyond the visible limits. The thermometer sometimes rose higher in the dark region than in the midst of brilliant zones. The light of the sun, then, contains, besides the colored rays so well characterized by Newton, invisible rays, still less refrangible than the red, and whose warming power is very considerable. A world of discoveries has arisen from this fundamental fact.

The dark ray emanating from terrestrial objects more or less heated also became the subject of Herschel's investigations. His work contained

the germs of a large number of beautiful experiments more fully developed in our own day.

By successively placing the thermometer in all parts of the solar spectrum, he determined the illuminating powers of the various prismatic rays. The general result of these experiments may be thus enunciated: The illuminating power of the red rays is not very great; that of the orange rays surpasses it, and is in its turn surpassed by the power of the yellow rays. The maximum power of illumination is found between the brighest yellow and the palest green. The yellow and the green possess this power equally. A like assimilation may be laid down between the blue and the red. Finally, the power of illumination in the indigo rays, and above all in the violet, is very weak.

The memoirs of Herschel on Newton's colored rings, though containing a multitude of exact experiments, have not contributed much to advance the theory of those curious phenomena. I have learned, from good authority, that he himself held the same opinion. He said that it was the only occasion on which he had reason to regret having, according to his constant custom, published his labors immediately as fast as they were performed.

LIFE AND LABORS OF HENRY GUSTAVUS MAGNUS.

[FROM THE ARCHIVES DES SCIENCES PHYSIQUES ET NATURELLES, GENEVA.]

Translated for the Smithsonian Report.

The processes of scientific investigation have never been reduced to definite rules, and frequently methods are adopted of the most opposite character. Sometimes, impelled by the impulse of his genius to achieve immediate distinction the scientist discards beaten tracks and attempts to explore new regions by assays almost without a definite plan in a predetermined direction, and although the results of his trials in most cases are of a negative character, yet he occasionally lights upon facts rich in the indications of scientific principles. Sometimes, less a lover of novelty than of precision of knowledge, he prefers the critical examination of some region previously traversed by others in order to give it that minute investigation required in every part of the domain of modern science, and thus unostentatiously contributes essentially to the advance of science. These two methods are both fruitful and should not be entirely separated. The first, perhaps the more brilliant, requires an undaunted spirit, a creative genius. The second, more modest, but also more sure, requires extensive erudition, a critical mind, and great talent for experimentation.

The scientific career we are about to portray belonged essentially to the latter class. The part of Magnus was less to discover new phenomena than to reinvestigate and render more definite those already known. Such was the precision of his researches that he was frequently enabled to draw new truths from subjects apparently exhausted, and, in some cases, even to transform entirely, propositions generally admitted as truths. He valued little bold conceptions and even ingenious hypotheses when not supported by rigorous demonstration, while a fact apparently the most insignificant he would frequently regard as of the highest importance, provided it was fully established. Exact and conscientious in the extreme, he concentrated his efforts upon the minutiæ of his investigations, removing with the greatest care every cause of uncertainty. Of cautious and candid judgment he was not ready to find his scientific colleagues in error; and when a disagreement occurred between his results and those of another, his first impulse was to look for a mistake in his own experiments. Essentially modest, loving science for its own sake, and forgetful of self, he did not shrink from the most arduous labors, from investigations apparently the most unremunerative, and in this way, without ostentation, almost unconsciously he gained a solid and lasting reputation.

Henri Gustave Magnus was born in Berlin, May 2, 1802. He belonged to one of the most honorable families of that city. From his earliest infancy he manifested peculiar aptitude for the exact sciences and preferred study to the ordinary amusements of childhood. He passed through all the grades at the academy of Berlin, and received the degree of Doctor in 1827. His first researches were made in the laboratory of Mitscherlich; he next pursued his studies under Berzélius at Stockholm, where he passed the year 1828. Thence he went to Paris where, in the laboratory of Gay Lussac he prepared himself for the interesting experiments which he undertook a few years later. Returning to his native city he soon obtained a reputation as an instructor, which he ever after sustained with great distinction and unflagging zeal. He entered upon this career as private tutor; was nominated in 1834 extra professor, and in 1845 ordinary professor of physics and technology in the university of which he became one of the brightest ornaments. He exercised an important influence in developing a taste for the study of physics, as well as in imparting a knowledge of its principles in their most varied applications. For the illustration of the subjects of his lectures he formed the physical cabinet of the university, which was enriched after his death by the valuable collection of apparatus belonging to himself.

His first labors were devoted to physical chemistry. In 1825 he contributed to this branch of science, through the *Annales de Poggendorff*, an interesting memoir, on the property which iron, cobalt, and nickel, finely divided by a reduction of their oxides in a current of hydrogen, possess of taking fire spontaneously in the air at the ordinary temperature. He did not confine himself to the mere discovery of the fact, and to showing that it was an especial attribute of these three metals, but explained it on the principle of De Saussure, of the absorption of gas by porous substances, such as charcoal, and by showing that substances of this character, in consequence of their porosity, condense oxygen and enter into combination with it so energetically as to produce incandescence.

In 1828 he discovered the compound which has been called, in compliment to him, the green salt of Magnus. This is formed of the elements of chloride of platinum and of ammonia, and was the first of a series of combinations of the same substances. In an investigation in common with Ammermüller, he discovered the periodic acid, also the ethionic and istheonic acids, analyzed a large number of minerals, and observed the remarkable property which certain crystallized silicates possess, of losing by fusion a considerable portion of their weight.

We cannot stop to enumerate all the investigations of Magnus in this branch of science; we must hasten on to his numerous and beautiful researches in physics, which constitute his true claims to renown. These were especially devoted to molecular and calorific phenomena. His first work on physics, entitled "Researches on Capillarity," is rather a study of the flow of different gases, through minute cracks in glass vessels.

He throws new light on this subject, and shows the remarkable fact that there is an immense difference in the rapidity of the escape of hydrogen in comparison with other gases.

He published later some interesting observations upon evaporation in capillary tubes, which he found most rapid in the narrowest tubes, and upon the boiling of mixed liquids. In regard to the latter, he showed, as theory indicated, that this boiling takes place at the temperature when the sum of the tension of the mixed vapors is just sufficient to overcome the pressure of the atmosphere, consequently at a temperature a little lower than the boiling-point of the more volatile liquid. He observed that this condition is never realized when the more volatile liquid is placed below the other; the mixture in that case becomes overheated and commences to boil suddenly with a violent explosion.

It was also at this period of his life, in the commencement of his career as professor, that Magnus made his interesting experiments upon the gases contained in the blood. This subject has since been further developed, but the honor will always be his, of having materially enlarged the views entertained in regard to one of the most important functions of animal life. The theory of respiration most generally received before his day, was that of Lavoisier, according to which, the combustion of the blood takes place at the moment when it comes in contact with the air in the lungs. This theory was, in fact, the only one then possible, since the presence of gas in the blood, emitted by expiration, had not been shown. Magnus found in arterial as well as venous blood considerable quantities of oxygen, nitrogen, and carbonic acid. The sum of these three gases was, in his experiments, equal to the eighth part of the entire volume of gas. He found that in arterial blood the oxygen was from one-third to one-half; of the carbonic acid in the venous blood only one-fourth to one-fifth. From this he concluded that the oxygen does not combine immediately in the lungs with the carbon of the blood, but absorbed by the arterial blood it is carried into the capillary vessels, where it is employed in the combustion of the debris of the organisms. Carbonic acid is in this way produced, which is also absorbed and transported by the venous blood, and is breathed out at once on reaching the lungs. This theory is now generally adopted.

The researches of Magnus, which perhaps more than any other tested his talents for experimentation, are those upon the coefficient of the dilatation of gases. It had been generally admitted that this coefficient was the same for all gases, and that between 0° and 100° C. their volume increased for each degree 0.375 of their volume at 0. This law of Gay Lussac, confirmed by Dulong and Petit, had passed into the domain of undisputed facts, when, four years after the publication of the works of the French savant, a Swede, Rudberg, revived the investigation of this question, and found as value of the coefficient of the dilatation of air 0.3646. It was important that a quantity so continually applied in physical science should be positively determined,

and simultaneously two of the most skillful experimenters of the time took up this important subject. Magnus communicated the results of his experiments to the Academy of Berlin November 25, 1841, and a few days after, December 13, 1841, M. Regnault gave to the scientific Academy of Paris his researches upon the same subject. These memoirs are master-pieces. Magnus says, in the opening of his: "I decided to take up the study of this important question, knowing well that I should gain very little, if any, distinction by the work, however long or laborious it might be, since its object was only to confirm one of two figures already known." This, the dictate of his excessive modesty, is the only error of his memoir. Contrary to his opinion, the work was one of his strongest claims to renown.

Repeating first the experiments of Gay Lussac, which consist in observing the dilatation under constant pressure of a certain quantity of air contained in a glass globe, by means of a small globule of mercury, which rises and falls according to the dilatation in the slender neck of this globe, Magnus soon discovered that there were several causes for uncertainty, but found as mean result of his experiments the figure 0.369 instead of 0.375, probably on account of the greater dryness of the air. He then tested Rudberg's method. His apparatus consisted of a tubular reservoir of glass, communicating with a manometrical apparatus, and inclosed in a triple envelope of sheet iron, in the interior of which any constant temperature desired could be maintained. By increase of pressure the volume at 100° was reduced to what it had been at 0°. A very simple equation resulting from the law of Mariotte gave the coefficient of dilatation with the difference of pressure observed. The value of the coefficient thus obtained for the atmosphere was a very little greater than that found by Rudberg. Not content with this important numeral, Magnus experimented with different gases, and found for hydrogen a coefficient of dilatation less than that of the atmosphere, viz, 0.365659; for carbonic and sulphurous acids, on the contrary, coefficients of dilatation greater than that of the atmosphere; for the former, 0.369087; for the latter, 0.385618. The law of Gay Lussac was but an approximation to the truth. Magnus proved that gases did not dilate equally, as had been until then generally admitted.

M. Regnault had made four series of experiments. The first two, in which he changed at the same time both the volume and the pressure, gave him two coefficients for the atmosphere, both equally sure, 0.36623 and 0.36633. The third and fourth gave, with the volume constant and the pressure varied, 0.36679 and 0.36650 as coefficients of dilatation for the atmosphere. While operating on different gases, he had arrived at results very nearly identical with those of Magnus. The two experimenters concluded to replace the old coefficient 0.375 by the figure 0.366 for the atmosphere, and decided that the different gases dilated unequally.

The cause of the difference between the figure found by Gay Lussac,

on one hand, and by Rudberg, Magnus, and M. Regnault, on the other, was that upon the interior surface of the vessel in which the dilatation of the air was observed, there was a stratum of humidity which passed into the gaseous condition when the reservoir was heated to 100°, and thus increased the dilatation. It was evident that an effect of the same kind might be produced by the condensation of the gas itself, on the surface of the vessel. To prove the fact Magnus ascertained two measures of the coefficient of dilatation of a single and the same gas, sulphurous acid, increasing greatly in one case the extent of glass surface in proportion to the volume of gas coming in contact with it. This was effected, by introducing a number of globules of glass into the reservoir containing the sulphurous acid. He obtained as coefficient of dilatation a value greater than by the ordinary process without the globules of glass, and while confirming the fact that gases condense at low temperatures upon solid bodies, gave at the same time the measure of this condensation.

After his researches upon the dilatation of the air at high temperatures and upon the tension of steam, finding himself again in competition with M. Regnault, Magnus left the field to be explored by the illustrious French savant, with far greater resources than he could command, resuming, however, at intervals, his favorite study of gases and vapors. In 1860 and 1861 he published a very important article upon the transmission of heat through gases in the double aspect of conductibility and radiation. Placing a thermometer in a glass vase heated moderately and filled successively with different gases or vapors, he found that the thermometer was heated differently in different gases, and indicated a lower temperature in any one of them than in a vacuum. He concluded from this that gases transmit very little if any heat by conductibility, and absorb a considerable portion of radiant heat. Only one gas, hydrogen, he declared an exception to this rule, at least as regards the first point; the thermometer rises higher in this gas than in a vacuum, notwithstanding, as he also observed, that it absorbs radiant heat in the same proportion as the atmosphere, azote, and oxygen. The thermometer rose higher when the gas was more dense, which seemed to indicate that gases conduct heat like the metals. This was one proof more in confirmation of the theory, making a metal of hydrogen, which has since been fully established by the beautiful experiments of Graham. This conductibility of hydrogen is well exhibited when it is surrounded by a non-conducting substance such as eider down or cotton, so that the currents produced in it may not be disturbed.

As we have said, all gases, without exception, absorb radiant heat, and in greater proportion as the pressure is greater. Those which absorb the least are the atmosphere, nitrogen, and oxygen, and, almost to the same degree, hydrogen. Among colorless gases, ammonia first, then olefiant gas, arrests most readily the radiations of heat. The difference in the transmission of radiant heat through different gases varies with the

sources of heat employed. The most marked differences are obtained from a source of black heat at 100° C. As to the vapor of water contained in the air Magnus observed that it was appreciably absorbent only when in the condition of a transparent gas. This subject gave rise to a long controversy between Magnus and Mr. Tyndall.

The English savant had undertaken the study of this interesting subject and gave the results of his investigations in a discourse before the Royal Society only a few days before Magnus communicated his to the Academy of Berlin. The two savants agreed upon all points, except upon the transmission of radiant heat through damp air. Contrary to Magnus, Mr. Tyndal found that the vapor of water contained in the air absorbed radiant heat forty, fifty, and even sixty times more than the air itself; and yet this result was obtained, not with air absolutely saturated with moisture, but with ordinary open air or with that of his laboratory. The want of accord between the two experimenters in this particular remains, in spite of repeated efforts to discover the cause in their different modes of operating. Magnus accounted for the enormous absorption obtained by Mr. Tyndall by the condensation of the vapor upon the interior surface of the tube used, or upon the plates of rock-salt which closed the extremity of this tube. The English savant repeated his experiments with the greatest care, but always with the same result. The error, on whichever side it exists, remains undiscovered, and some idea may be formed of the difficulty of this question when two such skillful experimenters fail to solve it.

Magnus made other interesting experiments upon radiant heat, especially upon the variation in the emissive power of a body with the degree of polish of its surface, and he showed that the increase of this emissive power in an unpolished body is greater, not because the superficial stratum is less dense, but on account of its discontinuity. He also observed that the increase in the emissive power of platina was confined to the radiations of red or nearly red heat. He discovered, also, the property which sylvine or chloride of potassium possesses, in common with rock-salt, of being almost entirely diathermal and of transmitting equally heat proceeding from very different sources. It was interesting to find a new analogy between these two substances, which in many of their properties, as well as in their chemical composition, are completely identical. In respect to the remarkable diathermality of rock-salt, we shall see how entirely he modified the theory of Melloni, which had been generally adopted.

Shortly before his death Magnus published a memoir upon the emission, absorption, and reflection of heat by bodies at low temperatures. This article, given entire in the Archives, shows that different bodies emit, absorb, and reflect, at temperatures in the neighborhood of 100° C., very different calorific radiations; so that were our eyes capable of perceiving the radiations of black heat, the bodies exposed to them would appear to us of very different colors, as is the case when they are

submitted to luminous radiations. According to Magnus, rock-salt is not in the least athermochroic, that is to say, diathermal, under any kind of heat; it is, on the contrary, monothermal, emitting and absorbing only a very limited number of simple radiations; just as incandescent sodium emits only a few of the yellow radiations and excludes all other kinds of light. This result, certainly very curious and unexpected, should be investigated in regard to other bodies.

Magnus, as we have said, especially applied himself to the study of heat, but he enriched other branches of science with numerous observations, all of which bear the imprint of his acute and accurate understanding. We will say a few words only upon his researches in thermo-electricity. Taking up the experiments of M. Becquerel, who attempted to show that in an homogeneous circuit heated at one point, electricity is produced because the heat emitted on both sides of this point differs in quantity, Magnus demonstrated that the production of electricity in the connected wire should not be attributed to the unequal transmission of heat in the two portions of this wire, but to an alteration in its molecular condition. After having confirmed the fact announced by Matteucci, that there is no production of electricity when two masses of mercury are brought in contact at different temperatures, he showed that an abrupt change of diameter, either in a column of mercury, or in a perfectly homogeneous wire, does not necessarily give rise to a current of electricity, but on the other hand, electricity may always be excited by heating the point of contact of two heterogeneous portions of a single wire, for instance, when one part is hammer hardened, and the other annealed.

This sketch would be incomplete without some notice of the numerous articles published by Magnus in the memoirs and monthly issues of the Academy of Berlin, and also in the *Annales de Poggendorff*, many of which have reappeared in the "Archives," either translated or reviewed. We must, however, confine ourselves to a mere mention of his researches upon the movement of liquids; upon the deviation in the rotary motion of projectiles; upon the temperature of the earth at great depths; upon the tension of mixed vapors; upon the electrolysis; upon the action of the brace of magnets, and upon the diffraction of light in a vacuum. Such were some of the various subjects which engaged his attention and which he pursued with unceasing accuracy and care.

But it was not only by his numerous and laborious investigations that Magnus advanced the cause of science; he filled the office of Professor; was, in fact, the leader of the university. He loved youth, and knew how to make himself beloved while imparting a taste for that science to which he had consecrated his life; and we may, without exaggeration, say that he exercised an important influence upon the scientific generation which has succeeded him. He received many testimonials of the confidence he inspired in the young men of the university; among others, we may mention, that in the troubles of 1848, to him, a man preëminently

devoted to order and duty, was confided the command of the university regiment.

His lectures, continued without interruption until near the close of the long and painful illness which ended his life, always attracted a large and attentive audience, which he captivated by the eloquence of his diction and the solidity of his instruction. A large number of young physicists frequented his laboratory, and learned of him judgment and method in the application of scientific principles. He also delighted to assemble them weekly at his house, and in familiar intercourse call upon each for some scientific contribution, however small, to be submitted to the criticism of his colleagues; thus training them in exposition and discussion. Several of his pupils have since become distinguished savants, and all remember, with lively gratitude, his kind, welcome, and generous hospitality in the laboratory of the *Kupfergraben.*

Magnus preserved to the end his activity and indefatigable zeal for science. At the close of the summer of 1869 he was first attacked by the malady of which he died a few months later. He endured with fortitude great suffering, continued his work and his lectures, and abandoned his post only when strength absolutely failed him. His death occurred on the 4th of April, 1870. His decease excited universal regret, and his name will ever retain a high and honorable place in the history of science.

SKETCH OF THE LIFE OF PROF. CHESTER DEWEY, D. D., LL. D.,

Late Professor of chemistry and natural history in the University of Rochester, and for many years a correspondent of the Smithsonian Institution.

BY MARTIN B. ANDERSON, LL. D., *President of the University of Rochester.*

Chester Dewey, D. D., LL.D., at the time of his death emeritus professor in the University of Rochester, was in two respects a representative man. He was not only a typical teacher, but he also held a distinguished position among the few who at an early day cultivated and organized the study of natural science in America. In these two relations we propose to speak of his life and labors.

Dr. Dewey was born in Sheffield, Berkshire County, Massachusetts, October 25, 1784. His father was a man of strong character and clear head, who seems to have had the will and the capacity to give his son a most symmetrical training, both moral and intellectual. In this work the father was aided by a wife of singular piety, cheerfulness, and moral excellence. It was doubtless to these early formative influences that Dr. Dewey owed much of that moral completeness which adorned the whole of his subsequent life. After a youth spent in alternate labor on the farm, and study in the common school, he fitted himself to enter the college at Williamstown, Massachusetts, in his eighteenth year. He graduated in 1806, taking rank as a scholar among the first in his class. During his residence in college he became the subject of those deep religious convictions, by which he ever after ordered his entire life. In 1807, he was licensed to preach by the Berkshire Congregationalist Association. After teaching and preaching for a few months at Stockbridge and Tyringham, Massachusetts, he was appointed a tutor in Williams College. After two years' service in this capacity, he was elected (at the age of twenty-six) professor of mathematics and natural philosophy. He held this position till 1827, a period of seventeen years. During this time the college was poor, and struggling for life. Of necessity, a heavy burden of labor and responsibility rested upon the officers of instruction. Among these, Dr. Dewey bore a distinguished part. In times of confusion and internal disorder, his influence over the students is said to have been most salutary and powerful. According to the custom of the time, his department of instruction included not only mathematics and physics, but the whole range of chemistry and the natural sciences.

He entered upon the work of accumulating and organizing the apparatus and collections requisite for the study of chemistry and natu-

ral history with great zeal and enthusiasm; while he was equally earnest in giving instruction in the severer portions of the broad department for whose cultivation in the college he was made responsible. He fitted up a laboratory, and commenced making collections for the illustration of botany, mineralogy, and geology. This was accomplished mainly by personal labor and exchanges with those engaged in similar pursuits in our own and other countries. These labors gave the initial impulse to the cultivation of the natural sciences in Williams College, and laid the foundations of its now large and valuable illustrative collections.

In 1827, Dr. Dewey resigned the chair which he had so long held. The friends of education in Western Massachusetts had been impressed with the necessity of providing more systematic and vigorous instruction for young men preparing for college and immediate business pursuits. An opportunity for public service of this sort of more immediate usefulness, as it seemed to him, than was afforded by his college chair, was found in the establishment of a gymnasium at Pittsfield. He removed to Pittsfield, where he had previously been engaged as professor of chemistry in the Medical College, and became principal of this institution. He remained in Pittsfield nine years, at the same time occupying the chair of chemistry in the medical colleges in Pittsfield and in Woodstock, Vermont. At the end of this period he removed to Rochester, New York, and took charge of the collegiate institute in that city. This institution, in connection with Professor N. W. Benedict, he conducted with high success for fourteen years. In 1850, at the establishment of the University of Rochester, he was elected professor of chemistry and natural history in that institution, and continued to discharge the duties of that chair for a little more than ten years. He retired from active duty at the ripe age of seventy-six. It was during the period of his connection with the university that I first became acquainted with Dr. Dewey personally and in the work of instruction.

In attempting an estimate of the services and worth of our venerated friend, we are naturally led first to speak of him as a teacher. In his chosen profession he was an enthusiast. His whole life was absorbed in obtaining knowledge and imparting it to others. In the street, in the social circle, in the professor's chair, he was always the teacher. No person could come within the sphere of his influence without carrying away some new fact or thought, or being inoculated with new love for moral or natural truth. In accumulating knowledge he seemed always to have in mind the idea of imparting it to others. In his mind new truths seemed to fall spontaneously into the form best adapted for presentation to the learner. He always conceived of nature and man as belonging to a common system, related to each other in every part, and designed to illustrate a common moral purpose. This naturally led him to estimate new investigations and discoveries to be important mainly as they served to set forth the moral dignity of man, to promote his

happiness, and elevate his character. His intellectual life was a beautiful commentary on the remark of Gibbon, that "it is a greater glory to science to develop and perfect mankind, than it is to enlarge the boundaries of the known universe." He appeared to study nature, not so much for the reputation which knowledge or discovery would secure to him, as from a tender affection for her various forms and aspects considered as exhibiting a grand connection of benevolent uses, means, and ends, revealing the goodness and wisdom of the Almighty. Hence, he was utterly free from those petty jealousies which so often manifest themselves among scientific men. He rejoiced in scientific progress, to whomsoever it was due, and was always most generous in his estimate of the achievements of others. Every discovery which developed new elements in the Divine plan was to him a matter for personal rejoicing. Whittier's verses, describing St. Pierre's sympathizing relation to nature, are more strictly applicable to Dr. Dewey than to the brilliant Frenchman:

> "She laid her great heart bare to him,
> Its loves and sweet accords—he saw
> The beauty of her perfect law.
> *   *   *   *   *   *
> And thus he seemed to hear the song
> That swept of old the stars along,
> And to his eyes the earth once more
> Its fresh and primal beauty bore."

To his mind there was no broad separation between the moral and the material order. But he was intensely averse to that false philosophy which seeks unity at the expense of reducing all thought and volition to dynamics, making no distinction between man and a crystal. To his mind, the whole scheme of material things was ever throbbing and quivering with divine life, benevolence, and power. This profound recognition of God in the modes in which He has revealed himself, rounded and completed his moral and intellectual life, and made him, by way of eminence, the Good Teacher.

His scientific attainments were supplemented by various and thorough knowledge in the department of critical scholarship. This gave a breadth and many-sidedness to his mind, which is so conspicuously wanting in many of the scientific men of our time. In the lecture-room, Dr. Dewey was exact and brief in his statements of principles; clear and full in his illustrations of difficulties; sympathetic with the dull in intellect, and patient with the wayward and inattentive. As a colleague, he was uniformly unselfish and courteous, bearing his share of all common burdens, ready to receive suggestions, never taking offense at trifles, exhibiting always that rare combination of natural qualities and acquired habits which distinguishes the Christian gentleman. He loved his work, continued in it during his whole active life, and neither sought nor wished for any other employment. It was his lot to have been connected with schools and colleges which have been recently founded

or were in the process of formation. For this reason his labors were the more self-denying.

He also represents two departments of the teacher's profession. He went from a college chair, in which he had been eminently successful, into an academy, and from an academy back again to a college chair, simply at the call of duty, apparently without a thought that dignity or position was in the slightest degree affected by either transfer. His only desire was to ascertain the position in which he could be most useful to his fellow-men. In view of these facts in our friend's career, I cannot forbear to note the lesson which they convey to our profession. As teachers, we should always bear in mind that we belong to a brotherhood laboring in a common work for a common end; that rank and dignity among us do not depend upon the accidents of position, but upon high attainments and faithful services, no matter where those attainments are made or those services rendered. In this respect the legal profession gives us a worthy example. From the Chief Justice of the United States to the village attorney, all lawyers, as members of the profession, are brethren, and equal. Let us frown upon any attempt to separate our profession into sects and orders, on the false assumption that there are, or can be, rival dignities or clashing interests among those engaged in the high and benevolent work of training the minds and characters of the young.

As a man of science, Dr. Dewey belongs to a class whose abilities and public services are liable, in our time, to be overlooked or underrated. I refer to those men who were pioneers in the work of cultivating and popularizing natural science in our country. When Amos Eaton, Parker Cleaveland, Robert Hare, Benjamin Silliman, Edward Hitchcock, and Chester Dewey began their labors, the natural sciences, as they are now understood, had in this country hardly an existence. Since that time the discoveries and investigations upon which they rest have, in great part, been made or matured.

Dr. Dewey left college in 1806. Just about this period that remarkable impulse was given to scientific inquiry, resulting in an almost simultaneous development of chemistry, zoölogy, crystalography, botany, and geology, which rendered the first half of the nineteenth century so supremely illustrious. What are now elementary truths, finding a place in every text-book, were then either undiscovered or new and strange, waiting the time of their acceptance or verification. The very year of Dr. Dewey's graduation, Davy made his discovery of the metallic bases of the alkalies, and promulgated the electro-chemical theory by extending and applying the discoveries of Galvani and Volta. A few years previous, Lavoisier and his associates had published their new system of chemical nomenclature. In 1807, Dalton's law of chemical equivalents and definite proportions was first given to the world. Häuy, Weiss, and Mohs published their new views on crystalography from 1800 to 1809, while Berzelius and others were at the same time developing the chem-

ical system of mineralogical classification. The natural system of botany, founded by the younger Jussieu, was, during this period, slowly making its way to public favor. Cuvier's "Fossil Bones," which first raised geology to the rank of a science, was not published till 1812. The "Animal Kingdom," which rendered a similar service to systematic zoölogy, appeared in 1817. William Smith, who, in England, was learning to describe strata in different parts of the island, and to identify them by their fossil remains, gave his results to the public about the same period, his most important work having been published in 1815. Many other facts in the history of science, which will occur to those who now hear me, illustrate the fact that our scientific pioneers labored under the disadvantage of having begun their career with the infancy of the sciences which they cultivated. They grew intellectually with the growth of natural knowledge, and their active lives stretched over the whole period during which these sciences were born and reached maturity.

The scientific attainments of these men were not made like those of young naturalists in our time, by the study of a body of coherent and established truths, or by the accumulation of new facts which take their places naturally under laws already verified, or fall into classifications already fixed and named. Their attainments were made amidst sudden and almost violent revolutions in method and changes in fundamental ideas, which were startling to the timid and bewildering to the weak. It required no ordinary courage and manliness, no ordinary faith in the universality and coherence of the Almighty's plan in the universe, to accept and promulgate ideas which seemed subversive of all established opinions—utterly superseding and setting at naught the "wisdom of the ancients."

The facilities for the acquisition of new facts, and the testing and verification of the new hypotheses, were inadequate in the extreme. Laboratories and apparatus were to be created or invented. Cabinets of minerals were meager, and collections of fossils were almost unknown. A single illustration in point we give from an article in Silliman's Journal for 1865. It will be borne in mind that Professor Silliman, senior, was appointed professor of chemistry and natural history in Yale College in 1805. The college was then over a century old, and under the presidency of Dr. Dwight. We are told that "not only the chemical laboratory, but also the cabinet of minerals, owed its existence to his [Professor Silliman's] energy. * * * About the time when Mr. Silliman was appointed a professor, the entire mineralogical and geological collection of Yale College was transported to Philadelphia in one small box, that the specimens might be named by Dr. Adam Seybert, then fresh from Werner's school at Freiberg, the only man in this country who could be regarded as a mineralogist sufficiently trained for that work." This illustrates the facilities for the study and illustration of natural science at Yale College, and we can readily infer the discouraging circumstances under which Dr. Dewey began his work and collec-

tions in Williamstown. Such facts ought to impress the present generation with an idea of the zeal, energy, and ability of men who, in such a state of things, could devote themselves to scientific pursuits.

It should be recollected, also, that these pioneers in science were not left free to devote any considerable portion of strength and time to investigation and the accumulation of specimens. They were generally overburdened with the work of giving instructions in subjects now distributed into three or four departments. Transactions of learned societies were procured with difficulty. Scientific journals were few, and in our country unknown. Communication with Europe was slow and expensive. The languages of modern Europe had not then been introduced into the courses of public education, and few, comparatively, could command the time or means to acquire them, or to travel abroad for the purpose of observation and study. These sciences, themselves, being in a formative state, were not differentiated, nor their limits marked out. These men, of necessity, studied nature in the mass, meeting often the unclassified subject-matter of several sciences in a single investigation. They constantly encountered the difficulties resulting from faulty and incoherent terminology. Their memories were burdened in keeping abreast with the changes of names which rapid scientific progress made necessary. Classes as well as names were in a state of constant flux, for we all know that an adequate terminology always follows and never precedes the knowledge of systems and laws. Their experience confirmed the maxim of the French savan, that "science est un langue bien fait." The tax upon time and memory, requisite to keep abreast of the rapid movement of thought and discovery, was enormous. Their mental experience became a register of the mass of the false hypotheses, blunders, changes, revolutions, discoveries, and generalizations which make up the brilliant and varied history of modern science. They were obliged to acquire an equal facility in learning and unlearning. The task of laying aside what had been painfully acquired, and which some brilliant discovery had suddenly proved to be useless or erroneous, was severer than the acquisition of what was new.

In addition to all this, they were obliged to make a place in an already occupied curriculum of college study, for their favorite studies, and to vindicate to the public mind their dignity and value. Like the early settlers of our unbroken forests, they were obliged to remove obstacles, and furnish a career for those who were to come after them. It is not strange, then, that the attainments of such men were affected and modified by the conditions of their scientific life—that their knowledge was less specific in its form, less methodical in its arrangement, than that of their successors at the present day. It is not strange that in the presentation of subjects they did not take note always of those metes and bounds which the accumulated thought of half a century has set up—that their mental furniture was encyclopædic and compendious, rather than minute, classified, and exhaustive. The immense range of the natural sciences, now that the work of evolution has been so far com-

pleted, makes specialization in study a necessity. But it may be carried too far, both in the neglect of general culture in the scientific investigator himself, and in the failure to attend to branches of science cognate to that specially chosen for cultivation. We believe that in the end nothing is gained to science by the neglect of those elements of scholarship which belong, by common consent, to liberal education, in order to concentrate the activity of an entire life, from boyhood to age, upon a particular branch of science. Against such a course the whole example and precept of our scientific fathers was directed. There is, in our own time, a tendency to confound the spheres of professional and general education, and to sacrifice liberal culture to special attainment. This seems to me an evil which should be resisted. A distinguished chemist remarked, not long since, that it was a cause for constant regret that his students in analytical chemistry came to him so often without liberal culture and discipline in letters, and general scientific knowledge and method.

We may also question whether the disposition to specialize, among investigators and professional scientific men, may not be carried to excess. May not what is gained to science in the more rapid accumulation of facts, through exclusive devotion to some narrow range of inquiry, be more than lost through the resulting deficiency in breadth of view? A man who carries specialization to extremes, will become intellectually purblind, and fail utterly in an adequate comprehension of the material and moral cosmos, considered each as parts of one vast whole, finding its unity in the mind of God. Said a great naturalist, the other day: "I am more and more convinced of the solidarity of the sciences. I am more and more inclined to distrust the observations of a man who is familiar with but one narrow branch of inquiry." Does not knowledge, by such specialization, grow faster than wisdom, breadth, and power? The effect of extreme division of labor, in manufactures and trade, in diminishing general capacity, intellectual and physical, has been often noted by economists. The guardians of public education, as well as of scientific progress, may well be warned of an analogous danger. "The more deeply the sciences are investigated," says a great historian, "the more clearly is it seen that they are all connected. They resemble a vast forest, every tree of which appears, at first sight, to be isolated and separate, but, on digging beneath the surface, their roots are all found interlaced with each other." Whatever advantage comes from a broad survey of the field of scientific inquiry, accrued to our scientific pioneers from the very necessities of their position. The broad, catholic sympathy of these men with all branches of science, stands in sharp contrast to that narrow scientific sectarianism which has too often disgraced scientific associations on both sides of the Atlantic.

At a time when scientific men of certain sympathies and opinions speak of religious men as obstacles to scientific progress, it is well to bear in mind the fact that the fathers of American science were, almost to a man, earnest believers in the divine authority of Christianity. The

institutions of learning in which, and through which, they labored, were all of them founded, endowed, and sustained through the efforts and sacrifices of religious men, and especially of the clergy. The pursuits of physical science are superficially thought unfavorable to moral and religious growth. But so long as we can recall the elevated spiritual life of such men as Silliman, Hitchcock, and Dewey, we need no other refutation of such an idea.

In connection with his labors in giving instruction in colleges, medical schools, and academies, Dr. Dewey was not unmindful of his obligations to make some additions to the sum of scientific knowledge. He was for forty years a constant contributor to Silliman's Journal. He always studied with pen in hand, and was a constant writer on scientific subjects for the newspaper press. He became early in life an enthusiastic student of botany, and contributed very largely to the scientific knowledge of the *carices*. Dr. Asa Gray, our great botanist, classes Dr. Dewey with Schweinitz and Torrey, and speaks of his writings on caricography as an "elaborate monograph, patiently prosecuted through more than forty years." He further says that, in connection with the two botanists above mentioned, "he laid the foundation and insured the popularity of the study of the sedges in this country." Unfortunately, Dr. Dewey did not write any systematic treatise on this subject, but his numerous short articles represent the progress of his own observations and studies, and give a history of the progress of that department of botanical science. Dr. Dewey wrote a History of the Herbaceous Plants of Massachusetts, which was published by the State. He contributed, also, the article "Carices," to Wood's Botany. Up to the last year of his life, our friend's mind showed the vigor and enthusiasm of his early years, and he was constantly writing on scientific topics. His last publications of any length were two review articles, one entitled "The true place of man in zoölogy;" the other, "An examination of some reasonings against the unity of mankind." These articles were read first before a literary association in Rochester, of which the Doctor was a member. They displayed a full and intelligent familiarity with all the most recent discoveries and speculations bearing upon these difficult and complicated questions. His discussions were conducted with an ability, clearness, and learning which, at his age, were surprising. His industry in study was unremitting, and up to the very last year of his life his mind was open to examine, with utter freedom from prejudice, any new discovery or speculation which was worthy of attention. His last labors were the orderly arrangement of his large collection of sedges, which had been for so many years accumulating on his hands, and copying out his meteorological journal. Just before his death, while engaged upon his journal, his hand became unable to hold his pen, and, calling for the aid of his daughter, he placidly remarked that this would be his last report to the Smithsonian Institution. He died calmly, of old age, on the 15th of December, 1867, in his eighty-third year. He

had the control of his faculties to the last, sustained by an unfaltering trust in the blessed life hereafter.

A few remarks further, and we close. All who knew Dr. Dewey were impressed with the freshness and vigor of his mind even up to the latest period of his life. I have often asked myself this question: How did Dr. Dewey retain so fully his mental activity, and grow old so gracefully? This result seemed to me due, in the first place, to his constant effort to keep abreast with the movement of modern discovery and thought. He never was satisfied with falling back on past experience or old attainments. He believed that morally, intellectually, and physically, man is making progress. He held it to be his duty as long as he lived to contribute to that progress, and to be himself a vital part of the movement. He was always at work; always acquiring new ideas. Morally and scientifically, his mind and sympathies were with the future, and not with the past alone. Hence, his brain never became inactive; the currents of his intellectual life never grew stagnant and dull. His topics of conversation were always of the present and the actual, or of some new application, modification, or adjustment of the old and the tried.

Again, he kept up, in a wonderful degree, communion and sympathy with the young. With them he established friendships and intimacies. In these intimacies, his stores of knowledge and ripened wisdom were poured out freely, while the young gave back to him the cheerfulness, confidence, and hope natural to their time of life. He was always a guide and helper to young and struggling men of talent. The number of such who, by his impulse, advice, and encouragement, were led to honor and success, was very great. No young scientific laborer ever failed to find a wise and sympathetic friend in Dr. Dewey. Nothing gave him greater joy than the rising distinction of some protegé whom he had started on the road to fame. His beautiful old age most emphatically belied Horace's oft-quoted description of the aged man:

> "Difficilis querulus laudator temporis acti
> Se puero, castigator censorque minorum."

No one was more warmly welcomed in society, by old and young, than he.

He kept his youth, too, through the simplicity, purity, and elevation of his moral and religious life. His trust in the moral order was as habitual and as firm as it was in the law of universal gravitation. This gave steadiness to his moral action, and so abated the ordinary friction and annoyances of life, that he seemed, to a casual observer, almost insensible to their action. For fifteen years I was favored with the friendship of Dr. Dewey. A large part of that time I met him daily as a colleague. I was associated with him during the period (always trying to an old man) when, at the age of seventy-six, he ceased to discharge the active duties of his chair; and I can say, with perfect sincerity, that to me and his colleagues he seemed incapable of injustice

or bigotry, of meanness or malice, of envy or suspicion. We all honored him as a sage; we loved him as a father. I have never yet met a man who so completely, as he, illustrated the moral elevation and spiritual beauty of the Great Teacher's Sermon on the Mount. What he was to his family and friends, he was to the multitude who knew him but partially and indirectly. To the whole population of Rochester his presence in the streets was a benediction

THOUGHTS ON THE NATURE AND ORIGIN OF FORCE.

By William B. Taylor, of Washington.

The great generalization of our age—the continuity or indestructibility of force—confirmed as it is by a constantly accumulating series of inductions, contradicted as it is by no adverse fact, comes gradually to impress itself upon our convictions almost with the positiveness of an axiom. And yet a slight consideration will show us that it is really but a corollary from the particular constitution of matter presented constantly to our observation. Had we any example of an incompressible substance wholly devoid of elasticity—that is, possessing no molecular or atomic repulsion, (to adopt the conception entertained by Newton and his followers,) but endowed with only cohesive and gravitative attractions—then for such matter the theory of the conservation of force would not be true. Were two equal balls of such a material to meet in space with equal and opposite velocities, at the moment of impact there would be, with the arrest of motion, the actual destruction of the entire living force they jointly possessed. Not only would there be no rebound, but there would be no internal molecular work effected, and no heat generated to represent a surviving or transformed energy.

The doctrine of the correlation and conservation of forces depends therefore upon the coexistence in all matter of two opposing tendencies, namely, those of *attraction* and *repulsion;* and from the ceaseless play and struggle of these opposing tendencies are derived ultimately all the varied phenomena of the visible universe.

The most ordinary and obvious manifestations of force are those exhibiting motion; as in the whirlwind and the cataract, the volcano and the earthquake, the steamship and the locomotive train. There has accordingly been a very general tendency to confound force and motion; and this fallacious confusion has not unfrequently vitiated the reasonings of even intelligent writers.

To distinguish, however, motion from force on the one hand, it may be remarked that they never have a common measure; and to distinguish force from motion on the other hand, it is only necessary to consider the fact that we are surrounded by a vast array of *statical* forces, continually resisting the most energetic solicitations to motion.

First, as to the absence of a common *measure:* It is found that the rate of motion follows only the law of the square root of the force originating it. A double consumption of fuel will not double the speed of a locomotive-engine. On the contrary, (as is well known to the engineer,) four times the quantity of fuel is necessary to attain this duplication of

effect. So if a pound of gunpowder will impel a cannon-ball with a given velocity, it will require four pounds of powder to double that velocity. The conservation of force, however, is maintained in the fact that the penetrating power of the cannon-ball is directly proportional to the energy expended in its propulsion; or, in other words, to the square of its velocity. Or, to express the distinction in the established formula, while $m \times v$ represents the quantity of *motion* in a moving body, $m \times v^2$ represents its quantity of *force*.

Secondly, in regard to *static* force: Every one who has ever attempted to hold aloft a heavy weight as motionless as possible will have had a realizing sense of the expenditure of energy required, not to *produce*, but to *prevent* motion. The Suspension Bridge at Niagara, safely upholding its thousands of tons of loaded cars and human freight over the frightful chasm beneath, may be cited as one among an infinite number of examples of statical force, or of *power in repose*.

The avalanche, hurtling down the mountain side with destructive violence, overwhelming a village and its inhabitants, is but expending a force stored up a year or years before, by the sun, when it lifted the mass, molecule by molecule, to its position of latent or potential energy.

Every pound of coal possesses a static or potential force of ten million "foot-pounds." That is to say, the power expended by the sun in raising the pound of coal from its low estate of chemical combination, or a satisfied affinity, to the higher plane of isolation and capacity for chemical reunion, was a power capable of lifting one thousand pounds of water to the height of ten thousand feet. And, conversely, the pound of coal thus chemically raised has itself received the power of mechanically lifting that immense weight to that enormous height.

It must be borne in mind, however, that when the sun actually does lift a thousand pounds of water to the height mentioned, it does not raise it bodily as water; it performs the vast additional labor of tearing asunder the entire mass, molecule by molecule, in opposition to the statical force of an intense cohesive attraction: a work of more than ten thousand "foot-pounds;" an expenditure of energy greater than that required to grind the same weight of ice (one thousand pounds) to the most impalpable powder. Deducting, therefore, this expenditure (a little over ten thousand "foot-pounds") we should find that the pound of coal represents, in a static form, an invested power equivalent to the lifting of one thousand pounds of water a little more than one foot, in addition to the task of evaporating the whole amount.*

Matter in motion being thus merely a vehicle of force, it follows that wherever dynamic or kinetic energy is transformed into potential energy, (as in pumping up water into an elevated reservoir,) there motion is to this extent destroyed; wherever potential or static energy is transformed into dynamic, (as in the discharge of a loaded pistol,) there motion is

* This of course does not include any actual *heating* of the water. One pound of coal will raise thirteen thousand pounds of water 1°; which is equivalent to only seventy-two pounds of ice-cold water (32°) raised to the boiling point, (212°.)

created. A very striking example of the continual transformation back and forth of these two conditions of force is presented in planetary movements, especially in those of considerable eccentricity. Taking the case of a cometary orbit, for example, whose greatest elongation should extend beyond the distance of Neptune, while its perihelion should lie far within the orbit of Mercury, we should find that the body, rushing or falling toward the sun with accelerated rapidity, would finally acquire a velocity of a hundred or two hundred miles per second; when its accumulated momentum would suffice to hurl it off as a projectile to its remote aphelion, where its velocity would be reduced to two or three miles per second, and the body be again in a condition to repeat its mighty oscillation. And this majestic pendulum, occupying some three-quarters of a century in its excursion, while exhibiting successively so enormous an absorption and alternate generation of motion, would at the same time illustrate the constancy and indestructibility of its force, in its transformation from the latent to the actual, and *vice versa;* the *vis-viva* of its lowest speed, plus its co-existing potential of gravitation at highest elevation, being exactly equal to those of its highest speed and lowest fall.

And yet, obvious as these truths appear, an acute and comprehensive thinker in an admirable exposition of the doctrine of evolution, has devoted a chapter to the unfortunate fallacy of the "Continuity [or indestructibility] of Motion." If it be once admitted that motion can be transmuted into any other form of force, then of necessity it cannot exist also as motion. The loose brick balanced on the chimney top, ready at a sudden gust of wind to topple and to strike a passer-by to earth, has a potential force, imparted to it perhaps fifty years ago by the hod-carrier and the brick-layer who raised it and placed it in its seat of power. During all these fifty years it has lain there quiet. True, it has partaken of the earth's rotations and revolutions; true, it has responded faithfully to all the varying, never-ceasing vibrations of summer-heats and winter-colds; and in all this passive acquiescence it has but illustrated its inertia. But this is manifestly altogether foreign to what we are considering. Whence, then, the motion that, commencing with the fall from the chimney, hurled back the brick to the earth from which it had so long before been lifted? The blast that tilted it was but the trigger which set free its latent power. Shall we say that the original motion imparted to it was also *latent* during all these years? Such an expression as "latent motion" is but a senseless contradiction of terms. The cap-stone of the great pyramid, elevated to its dizzy height with much effort and labor, might possibly remain there unmoved forever.

The simple truth is, that so far from our having any warrant for the assumption that the sum of all the motions in the universe is a constant, the repeated creation and destruction of motion is on the contrary necessarily involved in the indestructible transmutability of force.

These considerations, of course, apply equally to all the various kinds of *molecular* movement, such as those of light, of heat, and of electrical currents. It is familiar to all that we can create heat, as when we kindle a fire in the stove, or pass an electrical current through an imperfect conductor, or simply rub two sticks together. It is equally familiar that we can destroy heat, as when we employ steam-power for welding, forging, rolling, or swaging iron, and measure the effective work performed in these operations by the amount of heat abstracted from the steam, and forever destroyed as heat. In brief, whenever heat or other movement has produced a changed effect in matter, either internally or externally, there and to that precise extent has the motion (whether molar or molecular) entirely disappeared.

It is true that we still hear the convenient term "*latent* heat" frequently employed; but while holding in all honor the researches of Black, who first unfolded to us the curious phenomena grouped under this title, we now know by the clear light of the dynamic theory that there is no such thing as *latent* heat; that if heat be not sensible, or actual, it is not heat at all. We now know that the 142° necessary to liquefy melting ice without any increase of temperature, and the 965° absorbed in effecting the evaporation of boiling water, have had to overcome great molecular resistances; and that the internal work thus performed in raising the water to a higher potential is exactly measured by the amounts of heat respectively thus expended and consumed. When, true to the eternal law of conservation, precisely similar amounts of heat are obtained by a reversal of the several processes, these temperatures are as much a new creation or transformation as when we ignite the carbureted hydrogen at our gas-burners, or the anthracite in our grates.

No one would think of saying (excepting metaphorically) that we were releasing the light and heat stored up—in the one case at the retorts of the gas-factory, and in the other in the carboniferous laboratory of the solar actinism—a million years ago. Heat latent in coal-fields which may perchance have lain immediately beneath colossal *glaciers* for thousands of years! As well might we speak of the blaze emitted by the petroleum lamp as original sun-light which has been latent all these millenniums.

Undoubtedly the more accurate designation of the fact is, that when motion has resulted in static condition, the motion is absolutely destroyed; when from that condition a succeeding motion is evolved, a new motion has been as absolutely created; that when one kind of motion has been transformed into another kind of motion, the *equivalence* of the two by no means involves the *identity* of the two.

Among the multitudinous metamorphoses of force presented to our observation, we find not unfrequent examples of motion rising higher than its source. These cases may, however, all be likened to the familiar illustration of a large weight on the short end of a lever lifting a lighter weight on the other end as many times as high; or to the par-

allel instance of a considerable body of water by its momentum raising a smaller quantity to a higher level in the hydraulic ram. Similar instances of water-power occur in nature, as at the mouths of rivers, and at estuaries, where the contracting channel transforms a large mass movement into the potential of elevation. A magnificent example of this is furnished in the Bay of Fundy, where a huge tide of seventy feet is derived from an ocean-wave probably not exceeding two feet in height.

As in visible or *mass* motion, the matter may be either falling to a lower state of power, (as in the descending weight of a clock or the falling water of Niagara,) or rising under a superior external propulsion to a higher state of power, (as in a clock being wound up or ocean-water being evaporated by the sun,) so in *molecular* movements, the matter may be either running down, (as in combustion, or in the decomposition of quaternary or ternary compounds into more stable binary compounds,) or the matter may be raised to higher power, (as in the vegetable deoxidation of carbon by the sun's rays, or in the building up of animal substance to more complex and unstable conditions, by the power derived from other matter running down.)

Now, in all these wondrously varied and complex transmutations of force, while it is certain that the sum of all the static and kinetic forms of energy in the universe is a constant, which the human race with all its endless appliances of machinery can no more increase or diminish than it can add to or subtract from the quantity of matter, yet it is equally true that the store of the former, or the potential in Nature, is being in the aggregate diminished by transfer to the condition of the latter or the dynamic; and that in this transfer the general tendency is to a form of temperature of greater diffusion, and less capability of further transformation. So that solar and planetary systems are constantly running down to a lower plane of power—the former by the radiation of high heat, the latter by the radiation of low heat—into empty celestial spaces.* There is on the whole, therefore, as Professor Sir William Thomson has well designated it, a "Dissipation of Energy."

In a paper "On a Universal Tendency in Nature to the Dissipation of Mechanical Energy," presented to the Royal Society of Edinburgh, April 19, 1852, Professor Thomson arrives at the conclusions, that "there is at present in the material world a universal tendency to the dissipation of mechanical energy;" and that "within a finite period of time past the earth must have been, and within a finite period of time to come the earth must again be, unfit for the habitation of man as at present

* The whole amount of solar energy incessantly expended on our earth may be estimated at the amount of 208 billion 498,027 million "horse-power"—a horse-power being equal to 550 foot-pounds per second. But as was shown by the illustrious Dr. J. R. Mayer in his *Beiträge zur Dynamik des Himmels*, (Heilbronn, 1848,) the amount of solar heat intercepted by the earth is to the whole amount radiated into space "as 1 is to 2,300 millions." (*On Celestial Dynamics.* Translated by Dr. H. Debus, *L. E. D Phil. Mag.*, April, 1863, Vol. XXV, p. 245.)

constituted; unless operations have been or are to be performed which are impossible under the laws to which the known operations going on at present in the material world are subject."* And in a communication to the British Association in September, 1861, on "Physical Considerations regarding the Possible Age of the Sun's Heat," Professor Thomson repeats, that "although mechanical energy is indestructible, there is a universal tendency to its dissipation, which produces gradual augmentation and diffusion of heat, cessation of motion, and exhaustion of potential energy, through the material universe."†

In glancing thus cursorily at the nature of force, and its more striking manifestations, it is hardly necessary to allude to the now recognized correlation of the organic and so-called "vital" forms of power with the purely physical and kinetic. It has been reserved to our own day to see established in all its fullness the grand dynamic equation—"*Causa æquat effectum.*" It has been shown by the most varied series of experiments and observations that physiological, like mechanical processes, are possible only on the sufficient consumption of fuel; that growth, and development, and muscular movement are derived from the oxidation of carbon and of tissue, whose products may be accurately measured; and are all but phases of the ever-changing, never-dying energy of Nature.

Perhaps each one who should consult his "consciousness" alone (that witness so important to the metaphysician) would feel a conviction that when he strikes a blow he is exerting an original and self-derived power. And yet it is certain that the will of an Alexander, a Bonaparte, or a Bismarck, would be as impotent to move a grain of sand without an adequate supply of pre-existing external force placed at its disposal, as to launch the Great Eastern from its ways without a similar supply.‡

* *L. E. D. Phil. Mag.*, October, 1852, Vol. IV, p. 304.

† Report of Thirty-first Meeting, &c., *Notices and Abstracts*, page 27. (Republished in the *L. E. D. Phil. Mag.*, February, 1862, Vol. XXIII, p. 158.)

‡ It is proper to notice here a caution which has been suggested, that the will, though admitted to be merely a starter or director of the animal store of material force, must still exert and therefore originate the power, however small, necessary for such initiation. Sir John Herschel, in an essay "On the Origin of Force," remarks: "The actual *force* necessary to be *originated* to give rise to the utmost imaginable exertion of animal power in any case may be no greater than is required to remove a single material molecule from its place through a space inconceivably minute; no more in comparison with the dynamical force *disengaged* directly or indirectly by the act than the pull of a hair-trigger in comparison with the force of the mine which it explodes. But without the power to make *some* material disposition, to originate *some* movement, or to change, at least temporarily, the amount of dynamical force appropriate to some one or more material molecules, the mechanical results of human or animal volition are inconceivable. It matters not that we are ignorant of the mode in which this is performed. It suffices to bring the origination of dynamical power, to however small an extent, within the domain of acknowledged personality." (The *Fortnightly Review* for July 1, 1865, Vol. I, p. 439.)

This directing capacity of the animal will, like that directing impulse which presides over the entire domain of organic evolution, eludes all analysis, and hence has no recognized dynamic equivalent. Without attempting to discuss here this very abstruse

A demonstration of this is seen in the case of motor-paralysis, (which may be likened to the state of a steam-engine with the cylinder-valves locked in position, or detached from the eccentric,) or in the case of that extreme prostration which follows a low fever or prolonged illness, (which may be likened to the condition of an engine whose head of steam is insufficient to overcome the inertia of the piston.)

But not only the animal processes of nutrition, growth, and movement are maintained *ab extra*, but those more subtle and mysterious processes of thought, emotion, reason, are alike the product of material metamorphosis; and their activities may be determined by the urea and the phosphates, and even phosphoric acid, eliminated by the kidneys. A large-brained man sitting idly in his easy-chair, with eyes closed to external impressions, and indulging in pleasant revery, might seem to be the very impersonation of self-contained and self-originating action. But apart from the chemical tests alluded to, which would demonstrate the fact of matter potential, undergoing a descent, we may employ the more direct and delicate indicator, a thermo-galvanometer, in connection with the back part of the dreamer's head, and we shall observe the needle to quiver and to fluctuate with the current of the varying thought. Let a knock be heard at the door, and though no movement of the face, no tremor of the closed eyelid betrays to the observer a consciousness of the sound, yet this tell-tale needle (sensitive to the two-thousandth part of a degree Fahrenheit) will attest by a deflection of many degrees of arc the aroused attention involuntarily excited through the action of the auditory nerves.* Here, then, we

point, it may be remarked that our faith in the doctrine of the constancy of force need not be shaken by this sole outstanding difficulty, or apparent limitation of its universality; and that however unable we may now be to explain or suggest the *how*—this last residuum, "will-power," (admittedly very small relatively to the product of voluntary force,) as well as that organic-power which determines that from the equal stores of force laid up in the two eggs of a duck and of an alligator, or of a dove and of a serpent, the one shall be directed to evolve a bird and the other a reptile—may yet be hereafter referred to the magazines each serves to unlock, or else to a principle entirely outside of mechanical force.

*In an interesting account of "Experiments on the Relation of Heat to Mental Work," by Professor J. S. Lombard, M. D., of Harvard University, employing a galvanometer capable of indicating about the five-hundredth part of one degree Fahrenheit it is stated that the ordinary variations observed resulting from mental action did not amount to more than about the fiftieth of a degree, though quite marked. "Pursuing these experiments further, it was found that anything that aroused the attention was capable of causing a greater or less rise of temperature on the part of the head, over and above that of the body." With the exercise of the higher reasoning powers, "the highest rise noticed did not exceed the twentieth of a degree," (about one-eleventh of a degree Fahrenheit,) while "the temperature of the extremities fell." "The most striking effects of all were produced by the reading aloud or the recitation of poetry." "Reading or reciting to one's self gave similar results, and often even in a more marked degree." "In the last-mentioned series of observations, it was not unfrequently found that the temperature of the forehead *fell*, while that of the back of the head rose; but for what reason, I have not yet been able to determine." (*The New York Medical Journal* for June, 1867, Vol. V. pp. 198–205.)

would seem to have almost the germ of a phrenometer, as if in defiance of the protestation that "thought cannot be measured." It is but just, however, to admit that this (although in some sense a phrenoscope) is not properly a phreno *meter*, since the effect determined is really only a resultant of the mental activity, and not its measure. The thermal indication represents (if the expression may be allowed) merely the friction of the mechanism.

On comparing the modes of derivation of force in machines (especially in those known as heat-engines) and in animals, we find that the transfer is made in substantially the same way. Matter previously raised to a chemical state of power is oxidized, and, in running down by this process of combustion, (whether slow or rapid,) evolves a molecular activity, which is absorbed and utilized in various ways, according to the exact seat of the transfer. Where deoxidized metals are the source of the power, (as in the galvanic battery,) the process is very similar. In this case, and in mechanisms operated by springs or weights, the potential force is first imparted by human labor.

The source of power, therefore, in machinery, as in the animal economy, is derived almost entirely from the vegetable kingdom; in which, matter which has been largely exhausted of its store of force by the engine and the animal, and discarded as carbonic acid, water, and other burned products, is raised again by the action of the solar energy to its static plane of chemical potentiality. And it is an interesting and significant fact that the two great vegetable staples consumed by the dead and by the living mechanisms respectively are identical in composition; that the *cellulose*, which is the principal food of the engine, is chemically isomeric with the *starch* which is the principal fuel of the animal. And the cellulose of the one, equally with the starch of the other, may, as is well known, be converted into sugar. It is hardly necessary to explain in this connection that the mineral coal so largely utilized, is itself but a metamorphosed cellulose; whose hydrogen and oxygen, (the elements of water,) expelled by geologic heat, have left remaining the carbon almost in a state of isolated purity.

Nor does it detract from the value of this parallelism between the diet of the inorganic and organic worker, that the latter (the animal) has not been so organized as to be capable of availing itself *directly* of the stored force in woody fiber; equal though it be to that which it has been adapted to assimilate.

It is important that we should endeavor to form some conception (however inadequate) of the physical mode of action and of derivation of the various forms of force presented to us. When a bell is struck with a hammer, the metal beneath is carried by the momentum or the *vis-viva* of the blow, beyond its condition of equilibrum due to the rigidity or molecular adhesion of the material; and then instantly recoiling, thus sets up a vibration counting tens, hundreds, or thousands to the second, according to the inertia, or the mass set in motion; which

oscillatory motion is finally destroyed only by external and internal resistances. In a manner somewhat analogous to this, the molecules of all matter balanced between opposing attractive and repulsive tendencies are forever ringing (so to speak) in response to continual disturbances, though with a rapidity inconceivably greater than any known as sound. Thus, when a gas-jet has its surface of contact with the atmosphere smitten with a spark or blaze, the molecules of oxygen and those of hydrogen and carbon rushing or falling together under the impulse of an attraction known as chemical affinity, with a violence so great as to impinge severely on their several spheres of molecular repulsion, set up a vibration whose velocity or pitch is measured by hundreds of millions, in the millionth part of a second.

When we examine other occasions of heat or molecular movement, we find the actions not dissimilar. Thus, in the case of *friction*, it is evident that the more prominent particles, pressed by either side between the rubbing surfaces, (not indeed by actual contact, but by what is equivalent, their repulsive spheres,) momentarily forced back within their repulsions and thereby compressing others, rebound with a vigor proportioned to the pressure ; and thus, like a spring, continue an oscillation, strengthened and accelerated by the duration of the raspings. So, when a body is subjected to percussion, we see how a vibration must be started, intense in proportion to the violence of the blow, as well as to the reinforcement of repeated action. In the fire-syringe, the volume of air already possessing a quantity of molecular motion due to the ordinary temperature, suddenly compressed into a very small space, must of necessity have the velocity of its particles greatly increased, and consequently the frequency and violence of the repulsive collisions correspondingly aggravated and intensified.

A similar conception may be extended to the thermal, chemical, and magnetic effects of electric currents, whether excited by frictional or by chemical disturbance, although the precise nature of the molecular movements is undoubtedly wrapped in great obscurity.

As has already been indicated, all applications of animal power may obviously be regarded as derived (either directly or indirectly) from the static chemical power of the vegetable substance by which the various organisms and their capabilities are sustained ; and this power, in turn, from the kinetic action of the sun's rays.

Winds and ocean currents, hail-storms and rain, sliding glaciers, flowing rivers, and falling cascades, are the direct offspring of solar heat. All our machinery, therefore, whether driven by the wind-mill or the water-wheel, by horse-power or by steam—all the results of electrical and electro-magnetic changes—our telegraphs, our clocks, and our watches, all are wound up primarily by the sun.*

The tides, with all their lifting power, (to which the largest ocean-

* The elder Stephenson, some fifty years ago, appears to have been the first to form the conception that his locomotive engines were really driven by solar power.

ships are as feathers,) and all their wearing action upon coast and river shores, are due partly to the sun's attraction, but in a much larger degree to that of the moon, an outlying portion of the earth's former equator.*

Not pausing to notice the various theories—more or less plausible—of chemical or of aqueous agency in earthquake waves and in volcanic ejections, we may, for the present purpose, regard these occasional outbreaks as the readjustments and vents of wide-spread pressure, from insensible settlings by the shrinkage of the earth's crust, resulting from the extremely slow cooling of the interior mass: the hardened envelope of stone or rock, a poorly conducting material, acting as a blanket which almost arrests the escape of the internal heat. And this heat, again, may be regarded but as a feeble residuum of that cosmical activity still notable in the sun and other stars.

Finding thus from observation that the sun is the great source of energy—static and kinetic—in almost all terrestrial phenomena, from the meteorological to the geographical, from the geological to the biological, we can only conclude that in the expenditure and conversion of *molecular movements*, derived from the sun's rays, must be sought the motive power of all this infinitely varied phantasmagoria. Thus, especially in the great store of *organic* force existing in the vegetable world, we must suppose that these subtle actinic vibrations, several times finer and higher even than those recognized as heat, have such relation to the molecular masses and inertia as by "forced" vibrations to overcome the powerful attraction of chemical affinities, and fairly to shake the particles into isolation, at the same time that other motions, photic and thermal, are expended in occluding in the plant structure the carbon thus deoxidized and divorced.

Tracing back these potent quiverings through the ninety-one and a half millions of miles of ethereal highway, along whose inconceivable

* Mayer, in his remarkable *Dynamik des Himmels*, discussing the retarding effect of the tidal wave on the earth's rotation by reason of friction, calculates that this is sufficient to have lengthened the day, within the last two thousand five hundred years, by one-sixteenth of a second. On the other hand, since the globe must have cooled somewhat within this period, (estimated at one-fourteenth of a degree Centigrade, or about one-eighth of a degree Fahrenheit, for the whole mass,) this would involve a contraction of the earth's radius (or a depression of its surface) amounting to about fourteen feet nine inches. Such a diminution of the equatorial leverage of rotation necessarily implies an acceleration of the motion, or a shortening of the day, very nearly equal to the opposite tendency, and counterbalancing it. "When our earth was in its youth its velocity of rotation must have increased to a very sensible degree, on account of the rapid cooling of its very hot mass. This accelerating cause gradually diminished, and as the retarding pressure of the tidal wave remains nearly constant, the latter must finally preponderate, and the velocity of rotation, therefore, continually decrease." (*L. E. D. Phil. Mag.*, 1863, Vol. XXV, pp. 409 and 427.) During the historical period, accordingly, it appears that the length of the day has reached its minimum, and has been sensibly constant or uniform, the rotation having greatly increased in the distant past, as it must as greatly decrease in the distant future.

essence they have so swiftly sped without the slightest loss,* we are brought at once to the great problem which has lately been so actively pursued—the origin of the sun's rays.

Assuming matter originally endowed with molecular attractions and repulsions, (regarding gravitation as resident in the primitive atom, though infinite in range,) and assuming such matter created in a state of power—that is, of extreme diffusion, or with its attractions wholly unsatisfied—we have all that is necessary to explain *dynamically* the existing order of nature. The great difficulty we have in forming satisfactory theories of the constitution of matter lies in the apparent complexity of the forces displayed. Thus we have at least five distinctly marked kinds of molecular attraction, each so characteristic that it cannot be converted into or mistaken for either of the others; and there are probably as many forms of repulsion. But starting with the idea of matter converging or falling together, we see how the encroachment of such a condensation on the repulsive spheres must give rise to a violent agitation; in short, to a heat vibration far more energetic or intense than any purely chemical action, by as much as the space-potential of gravity exceeds that of affinity; far more intense, indeed, than any temperature now probably existing in the sun.†

Here, then, in molecular gravitative attraction—as the ultimate resort, are we forced to accept the *primum mobile*—the origin of the power which has not only evolved and molded our solar family of worlds, but which has sustained our terrestrial economy in all the wondrous changes of its eventful career throughout the geologic ages. Beyond this fundamental conception of mysterious "attractions" forever resident in material elements, it does not appear probable that scientific research will be able to carry back the parentage or genesis of force. And yet there have not been wanting numerous hardy attempts to frame explanations and hypothetical antecedents of these postulated affections of atoms, or to replace them by dynamical agents or actions; while really leaving the problem of derivation as unsolved, or more insoluble than ever.

A laborious and ingenious French-Swiss physicist, Georges Louis Le Sage, about a century ago, devised the hypothesis that all space was occupied with extremely minute bodies, denominated by him "*ultramundane corpuscles*," moving in continuous right lines in all possible directions, with inconceivable but uniform velocity, and without collision

* The question is sometimes raised whether the light and heat of the sun and other stars may not be somewhat enfeebled or absorbed in passing through the celestial spaces. The doctrine of conservation of force teaches us that any absorption of either light or heat implies a proportionate amount of work being done, the consequenceof which would be a heating of *space* itself!

† A pound of coal falling to the sun from the distance of Neptune (which planet must be regarded as an ancient landmark of equatorial drift) would reach it with a velocity not very far short of four hundred miles per second; and the arrest of this motion would generate a heat vibration many thousand times greater than could be obtained from the combustion of the same pound of coal.

or interference; the total resultant of whose impacts on gross matter constituted gravitation. A single particle or mass of matter equally impressed on all sides by these universal projectiles would, of course, remain in perfect equilibrium. But two or more such bodies in space, screening each other on their facing sides, would be subjected to unbalanced impacts from these infinitely minute but powerful "corpuscles," and would thus be always urged toward each other in the directions joining their centers. No explanation of the origin of the enormous living force assumed in these winged motes was attempted. Although the law of the inverse square of the distance could be mathematically deduced from the assumption, the law of mass ratio was unfortunately not so well represented by it.

Sir John Herschel remarks upon this abstract speculation: "The hypothesis of Le Sage, which assumes that *every point of space* is penetrated at *every instant of time* by material particles, *sui generis*, moving in right lines *in every possible direction*, and impinging upon the material atoms of bodies, as a mode of accounting for gravitation, is too grotesque to need serious consideration; and besides will render no account of the phenomenon of elasticity"*

More recent speculators have supposed that *motion* explains everything; and they accordingly suggest the probability that all force—including gravitation—is a form of vibration. Observing the remarkable extension of the undulatory theory, first to light, and subsequently to heat, and perhaps mindful of the radiant law of diminution with the square of distance, they seem to have been led from this analogy) to overlook the consideration that no vibration is possible without two opposing forces; and so in substitution or in explanation of that which is itself simple they proffer a duplex causation. All such hypotheses have been projected under the impulse of the ancient *à priori* dogma, that "matter cannot act where it is not," or of the equivalent proposition, that *action upon a distant body* is "inconceivable!"†

Professor Faraday entertained a somewhat indefinite idea (borrowed from Boscovich's abstract centers of force) that matter must be continuous, or everywhere present, in order that forces may be transmitted by virtual contact. He says: "Doubtless the centers of force vary in their distance one from another, but that which is truly the matter of

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*"On the Origin of Force." *Fortnightly Review*, Vol. I, p. 438.

† It may be asserted in reply to this, that no scientific theory is final until its ultimate postulate *is* "inconceivable." "For if the successively deeper interpretations of nature which constitute advancing knowledge are merely successive inclusions of special truths in general truths, and of general truths in truths still more general, it obviously follows that the most general truth, not admitting of inclusion in any other, does not admit of interpretation. Manifestly as the *most* general cognition at which we arrive cannot be reduced to a *more* general one, it cannot be understood. Of necessity, therefore, explanation must eventually bring us down to the inexplicable. The deepest truth which we can get at must be unaccountable." HERBERT SPENCER, *First Principles*, (second edition,) Part I, Chap. IV, p. 73.

one atom touches the matter of its neighbors. Hence matter will be *continuous* throughout; and in considering a mass of it, we have not to suppose a distinction between its atoms and any intervening space. The powers around the centers give these centers the properties of atoms of matter; and these powers again, when many centers by their conjoint forces are grouped into a mass, give to every part of that mass the properties of matter."* And yet, in his earlier speculations, he says in regard to electrical action in a vacuum, "Suppose it possible for a positively electrified particle to be in the center of a vacuum an inch in diameter, nothing in my present views forbids that the particle should act at the distance of half an inch on all the particles forming the inner superficies of the bounding sphere."† This, as Dr. Müller has remarked, is certainly an admission of the dreaded *actio in distans;* but whether this view was subsequently modified is not very clear. Nor is it clear that Faraday, in affirming the presence of matter wherever it acts, had any other conception than that usually entertained by those who accept the atomic theory. To assert that our moon "touches" the earth, nay, that it embraces Neptune, notwithstanding its perfectly determinate boundary of material surface, is only to employ words in a wholly unintelligible sense. To affirm an infinitude of material interpenetrations is simply to ask the adoption of a new term instead of "matter," to represent that bounded *something*, or congeries of somethings, which all experimental research attests to be impenetrable.

Professor J. Challis, of the University of Cambridge, England, has proposed "A Theory of Molecular Forces," which he has presented in a refined mathematical exposition, in a series of essays published in the *Philosophical Magazine*, from 1859 to 1871;‡ and which, assuming the molecules of matter to be surrounded by a continuous ethereal medium of uniform elasticity pervading all space, resolves all forms of force into the *pressure* of this ether; each atom being the center of vibrations propagated from it equally in all directions.

Dr. Balfour Stewart, in an essay on "The Dynamical Theory of Heat," appears inclined to favor a somewhat similar view. He remarks: "Till we know what the ultimate nature of matter is, it will be premature to speculate as to the ultimate nature of force; though we have reason to believe that it depends upon the diffusion of highly attenuated matter throughout space."§

Professor Frederick Guthrie, in a paper read before the Royal Society of London, in 1870, "On Approach caused by Vibration," detailing some very interesting experiments showing small converging aerial currents resulting from tuning-fork vibrations, (in perfect accordance with the

* *L. E. D. Phil. Mag.*, February, 1844, third series, Vol. XXIV, p. 142.

† *Experimental Researches in Electricity.* Reprinted from the Phil. Trans., 1831–1838. Series xiii, sec. 1616, Vol. I, p. 514.

‡ *L. E. D. Phil. Mag.*, fourth series, Vols. XVIII, pp. 321 and 442; XIX, 88; XX, 280, 431; XXI, 65, 92; XXIII, 313; XXVI, 280; XXXI, 459; and XLI, 280.

§ *North British Review*, February, 1864; (Vol. XL, page 22, American edition.)

mathematical theory of hydrodynamics,) thinks he finds in these phenomena an explanation of force in general, including that of gravitation. He observes: "In mechanics—in nature, there is no such thing as a pulling force. * * * The line of conclusions here indicated tends to argue that there is no such thing as attraction in the sense of a pulling force, and that two utterly isolated bodies cannot influence one another. If the ethereal vibrations which are supposed to constitute radiant heat, resemble the aerial vibrations which constitute radiant sound, the heat which all bodies possess, and which they are all supposed to radiate in exchange, will cause all bodies to be urged toward one another."* Supposing that such resulting ethereal currents could have any sensible influence on planetary masses, it seems to be entirely overlooked that such currents would be of the most variable and fitful character. Every sun-spot would derange the planetary orbits; planets when cloud-clad would affect each other very differently from those having transparent or diathermanous atmospheres; and no resource of mathematics could ever predict an occultation or eclipse.

Were it necessary to discuss the question whether gravitation is either a form or a result of *motion*, the fact that its action is instantaneous, that it requires no sensible lapse of time to be felt by the most distant planet, is perhaps the most direct evidence bearing on the point. Were any interval of time occupied in the transmission of this influence from the sun to a planet, there would result a phenomenon of "aberration" (similar to that of light) by the amount of orbital motion occurring during the time of its transit, the consequence of which would be an acceleration and extension of the radius-vector, or a spiral *unwinding* and final dispersion of all the planets and their satellites. In general terms, the stability of a planetary system, or the conservation of mean distances, depends upon the absolutely *radial* and *immediate* action of the central attraction. Supposing, in the case of our earth, that gravity occupied even so short a time as the hundredth part of one second in passing over the ninety-one and a half million miles from the sun—during this interval (of the one-hundredth of a second) the planet would have traveled about one thousand feet in its orbit; and the resulting displacement or "aberration" of directive force would be about the twenty-five-hundredth part of one second of orbital arc. It has been shown that even this small deviation would have been noticeable in the two thousand years separating us from the time of Hipparchus. Arago has estimated that any possible *velocity* of gravitation must be, at least, fifty million times that of light!†

Gravitation, therefore, is not a motion; nor is it the product of any motion. We are forced to the conclusion, however "unable to conceive" the fact, that it is really an *actio in distans*, and that *ad infinitum*; that it is a force, a faint reflex of its Author, *instantaneously omnipresent.*

* *L. E. D. Phil. Mag.* for November, 1870, Vol. XL, p. 354; and June, 1871, Vol. XLI, p. 406.

† *Popular Astronomy*, English edition, Vol. II, p. 469.

In the peculiar phenomena of magnetism, we have reason to believe that the attraction (as in the cases of gravitation, cohesion, and affinity) is resident in the ultimate molecules, if not in the constituent atoms. However minutely we may subdivide a magnetic bar of steel or nickel, (cobalt or manganese,) we cannot separate the poles—the attractive from the repellant. However small these fissiparous segments, each is itself a perfect magnet, with equal opposite polarity.

It is evident that the arrangement of the molecules in a magnetic bar, all axially accordant in direction, must be one of constraint, since although a single line of such particles would find a stable equilibrium in that uniform direction of polarity which should satisfy the attractions of all their contacts, yet a second adjacent line, similarly directed, would constantly present to the first line the antagonism of connatural or homogeneous poles. Hence, to secure a general stability of equilibrium, the supposed lines of molecular magnets should be alternately reversed. But such an arrangement would result in a complete neutralization of the attractive and repulsive forces, and the mass or bar of metal thus constituted, possessing no internal differential resultant, would exhibit no traces of integral polarity or magnetism.

Assuming (as we have reason from various considerations to believe) that in all solids the constituent particles, however firmly locked by their cohesive forces in their fixed relations of distance and position, are yet capable of rotation within their magic spheres, without affecting their solidarity, we can easily perceive how, under the attractive induction of a powerful external magnet, a bar of iron constituted as just suggested would have at once its constituent molecules polarized in direction, and thus become a sensible magnet, while it would as quickly relapse from this condition of restraint on the removal of the controlling agency. The actual behavior of iron is exactly conformable with such an organization. The entire efficiency of the electro-magnet for the purpose of telegraphy depends upon this property of facile molecular rotation in the iron magnet, whereby it instantly becomes spontaneously *de*polarized on the suspension of the electric current.

Under the quaquaversal disposition of the molecular axes, thus shown to be the normal condition of equilibrium, it follows that the magnetism of matter, however powerful, should remain forever latent, and all its manifestations in abeyance, did not some potent interference disturb this neutrality.

If, however, we further assume that in very rare cases, as in that of nickel or of hardened steel, a considerable amount of adhesion (the nature of which we are unable to comprehend) exists between the constituent particles, preventing their easy rotation, then we can perceive that the presentation of a powerful external magnet to such a bar would not easily or at once induce a sensible magnetization. If, however, the solicitation of the attracting magnet were sufficiently powerful, and sufficiently continued, to overcome the resistance of this molecular

adhesion, we can also perceive that the particles, when once brought into a common polarization, would be likely to maintain their constrained axial position permanently, provided that the adhesive resistances of the molecules should exceed their magnetic resistances. Such a behavior we find presented by hardened steel, to which habit the name "specific coercitive power" has been given.

There is obviously no transfer of virtue from the magnetizing to the magnetized body. On the contrary, the former is actually strengthened by its evolution of the manifestation in the latter—a result in perfect accord with the supposition of a reaction of *mutual* preëxisting attractions.

It is familiar that by holding a bar of steel in the direction of the earth's magnetic pole, or rather of its magnetic dip, and giving the end of the bar a few taps with a hammer, we can at once induce the magnetic condition. Here obviously the molecular vibrations from the blow have facilitated the rotations necessary to bring the particles into axial accord.

The work expended therefore in developing the magnetism of a steel bar, whether by the mechanical passes of an artificial magnet, the long-continued induction of the terrestrial polarity, or the molecular disturbance of an eletrical coil, is simply that required to overcome the original resistances to the changed condition. The magnetic force, or dual forces, must be regarded as primitive, constant, unchangeable attributes of the ultimate particles of matter; as incapable of increase, of diminution, or of transfer, as gravitation itself. And the notable discovery of *diamagnetism*, by Faraday, leads us to believe that all matter has this polar quality indelibly stamped upon it in varying degrees; the molecules of nitrogen possessing it in the smallest degree of any known element.

Analogical reasoning would appear to justify the conclusion that *electrical* attraction and repulsion (capricious, ephemeral, and mysterious as they appear) belong to the same category of original and unalterable molecular properties, although it is by no means easy to give so rational an account of the phenomena observed as in the case of magnetism. The fact that both are *polar* forces, exhibiting a duplex action; that in both cases similar states or poles repel each other, and opposite states or poles attract each other; that these conditions of attraction and repulsion apply equally or indifferently to either pole; and that an opposing polarity may be induced by approach in other matter, would certainly indicate a very similar nature and seat of influence.

In the apparent transfer, however, of electricity by contact or discharge, and in the neutral equilibrium immediately resulting, there is an action *sui generis;* as also in its manifestation as a differential of chemical, or of thermal activities. In the mutual reactions of the magnet and the electrical current, still more puzzling phenomena are presented; and without attempting to discuss Ampere's ingenious theory of the "solenoid," the observed fact that each does exhibit a torsional or tangential

action upon the other is one which has no parallel or analogue in any other of the known natural forces. In the quasi-magnetic behavior of electrical currents, whatever the vehicle or electrode, occurs a further extension of the same peculiarity.

Notwithstanding all these difficulties, and the intimate relations of "dynamic" with so-called "static electricity," a more comprehensive and rational theory of this most abstruse subject may hereafter establish as radical a distinction between the molecular movements constituting electrical currents, and the molecular capacities of polarity, or of electrical attraction and repulsion, as has been found to exist between light or heat and chemical affinities or molecular repulsions.

Nor is the inference here suggested affected by the fact that Joule, in 1843, derived his first approximation to the mechanical equivalent of heat from experiments "on the calorific effects of magneto-electricity,"* any more than it is by the fact that we accept terrestrial gravity, at the earth's surface, as the standard of comparison for all forms of energy.

It was seen at the outset that the conditions of antagonistic molecular attraction and repulsion, such as we find in the actual constitution of matter, were essential postulates to the theory of the conservation or persistence of force. We have been led to the conclusion that these same antagonistic principles constitute equally the real, efficient *origin* of force. And though we are provided with no general term to embrace these primordial, indestructible, immutable, statical centers of force, and to distinguish them from those other derivative, evanescent, and convertible forms of energy, exhibited either in the potential of constrained position, or in the actual of changing position, yet the two classes appear to be so essentially dissimilar that it may well be doubted whether the language very frequently employed by writers to express the correlations and transformations of material forces is really an accurate statement of the fact.

If it be true that all phenomena of energy may be traced back ultimately to molecular attractions and repulsions as their primeval parents, and if these same attractions and repulsions are found to be persistent, ever-present, and unexchangeable, however frequently matter in its protean character may be shifted (so to speak) from the active dominion of the one to that of another, it would seem to be exceedingly improbable that, conversely, any form of molecular attraction or repulsion can be produced or derived from motion, or from the ordinary manifestations of dynamic energy.

If this be so, we are not warranted in speaking of the correlations of gravity, of cohesion, of chemical affinity, and of magnetism, in the same sense in which we apply the term correlation to the secondary or convertible forms of force, as among themselves, and as connected with their primaries.

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* Mr. Joule's paper, read before the British Association, August, 1843, was published in the *L. E. D. Phil. Mag.* of that year, Vol. XXIII, pages 263, 347, and 435.

INDUCTION AND DEDUCTION.

A DISCOURSE BY JUSTUS BARON VON LIEBIG.

DELIVERED IN THE ROYAL ACADEMY OF SCIENCES, MUNICH.

(*Translated for the Smithsonian Institution.*)

The ideas of the generality of men respecting the nature of scientific research are so imperfect and erroneous that it will not, perhaps, be without interest to many if I attempt to elucidate and complete the views which I advanced on this subject in a former discourse on Francis Bacon, of Verulam.

Philosophers pursue in general two methods of inquiry in regard to the phenomena or laws of nature, induction and deduction; they are in effect but different processes, while their object is the same; the distinction between them depends upon the point of outset; the deductive method sets out from generals, the inductive from particulars; in the combination of the two induction precedes deduction.

The nature of induction, according to Aristotle's view of it, may perhaps be best illustrated by the example which he himself gives of an inductive conclusion:

Man, the horse, the mule, &c., live long.
Man, the horse, the mule, &c., have little gall.
Therefore, all animals that have little gall live long.

This mode of conclusion, if so we must call it, is a very easy one to the inquirer; but what is here styled a conclusion is only the observation of the juxtaposition of two phenomena; scarcity of gall is a fact which accompanies long life; it is part of a whole, and the conclusion no syllogism, including in itself the reason of the dependence of longevity on the paucity of the secretion in question. We need only substitute in the middle term, instead of gall, any other simultaneous fact peculiar to certain animals, for instance:

Horses, mules, &c., live long.

Horses, mules, { have little gall.
have glycose in their muscular tissues.
have no uric acid, (*Harnsäura.*)
have (Hippursäura)

in order at once to perceive that the connection of these with longevity is purely arbitrary and rests on no operation of the understanding. The philosopher, for the explanation of a phenomenon of nature or of a process, seeks to assign a connection between the parts thereof which have come under his observation, and first of all sets out with the supposition, as regards two facts which constantly accompany the phenome-

non or process, that they postulate one another, or that one is dependent on the other; but this is merely an idea having no real basis for its support, but simply a perception which may or may not arise in the mind of any one.

Aristotle denoted induction as being the passage from particulars to generals, since, in physical inquiry, our first concern is with the knowledge of the phenomenon and afterward with its explanation; but in this sense it is clear that he regarded induction not as a *method*, but as a *rule* of investigation.

It is plain that if all the forces of nature and their laws were known to us, if we knew all things in their nature, action, and properties, the investigation of a particular process and its explanation would be a simple deductive problem; each single case would then be soluble through a conclusion of the understanding. Suppose, for instance, that the rusting of iron in the air were the point to be explained; the previous examination of rust has determined that it contains iron, oxygen, and water; the composition of air is also known; the elements, therefore, for explaining the process of rusting are before us, but further inquiry shows us that iron in oxygen in the presence of the vapor of water does not rust; there must, then, be some constituent principle of the air, besides oxygen and vapor, in order that iron should undergo the process of rusting; now we know that the air actually contains a very small portion of carbonic acid, and examination shows that a mere trace of carbonic acid suffices, with sufficient access of oxygen, to convert a large mass of iron into oxide; but the rust itself contains no carbonic acid. The question then is: What part does this acid play in the process? Another known fact now suffices to complete the explanation; this is the action of the oxidulated carbonate of iron; in damp air it attracts oxygen and is converted into the higher oxide which enters not into combination with carbonic acid; it is by the rusting of the metal that the lower oxide first originates, and this combines with carbonic acid, which through the passage of the oxidulate into free oxide becomes capable of exerting in a hundredfold degree its original action on the metal, so that gradually the whole piece is throughout converted into iron-rust. Inquiry further establishes that there is a special case where iron in damp air, even without the presence of carbonic acid, is thus rusted, when the air, namely, contains ammonia; but that in that case the rust does not extend, and that, lastly, an electrical process is coöperative with the rusting.

To this class of investigations belongs also that of the production of dew by Dr. Wells. That dew is a watery precipitate produced by refrigeration admitted of no doubt, nor that the modes of refrigeration were only two. The problem only turned upon the question, whether the conditions of the cooling were dependent on conduction or on radiation, which point was susceptible of determination by experiments guided by known laws.

To inquiries of this sort no exterior difficulties oppose themselves, and, for conducting them, knowledge and the correct appreciation of relations abundantly suffice; they rarely occur, because the physical inquirer, for most of his problems, does not find ready prepared the thought-material requisite for his mental process; it should also be remarked that by these our insight into the nature of phenomena is indeed rendered clearer and more thorough, but that the boundaries of science are not thereby enlarged.

In the great number of other inquiries, the inquirer is confronted by obstacles which, with the whole stock of knowledge furnished by science and with the most perfect powers of discrimination, he cannot remove, and these are new facts or phenomena which pertain to unknown laws, which are not accessible to the understanding from a deficiency of the intervening facts necessary to his ideas. For this class of inquiries there must coöperate, in the case of the philosophical inquirer, something which essentially characterizes his mind, and that is the force of imagination.

The sum of what we know respecting nature and its forces is, in fact, so small when compared with what we do not know respecting them, that the physicists of our times find themselves, in a majority of cases, precisely in the condition of those of the sixteenth century as regards those things which to them were unintelligible but to us are easy; there is for us, as there was for them, a defect of clearly comprehensible facts essential to the deductive process; in the failure of a single one of these the intellect stands before a chasm which it cannot fill up; in that earlier time the force of imagination was called in aid to an extent which we regard now as wholly inadmissible. The advantage we have over the early inquirers rests therefore not on increased intellectual powers or on the superior delicacy and penetration of our senses, but on a greater affluence of facts or experiences, that is, on an accumulation of materials for the operations of the understanding. Hence there is no doubt to be raised respecting our relative position; and yet there are but few who have a clear idea of the sources from which the constantly increasing store of these materials for thought is derived.

If we cast a glance backward on the history of the so-called inductive sciences, we at once recognize that for centuries they had the character of an art. Until Newton, astronomy and mechanics were arts; the same were physics until the time of Galileo; and chemistry up to that of Bergmann. Bœrhaave defines chemistry as the *ars docens exercere certas physicas operationes.*

Art and science are essentially distinguished from one another by their different aims.* That of art is the search for or the finding of facts; that of science is the explanation of them. By art, of course, we do not here mean any of the fine arts. The artificer seeks to attain an object; the experimental artificer seeks a thing. From particu-

* The aim of art is the discovery of facts; that of science the discovery of principles and laws.—J. H.

lars he would construct a whole. The man of science, on the other hand, seeks a reason or principle. From the whole he proceeds by its parts, even to the roots. As the artificer knows nothing of a principle, and a principle would be of no help to him, it will be understood that the process going on in his mind is no intellectual operation. The intrinsic character of his thought resides in this, that he thinks of sensible phenomena. As the understanding examines ideas, measures, as it were, determines and fixes their import, so that they become serviceable for deductive operations, just so does the inductive artificer proceed. He probes the phenomena with all his senses, and while he applies his faculty of perception, with all the tension of his will, to one property of a substance or one pecularity of a phenomenon after another, to the present exclusion of all others, his imaginative power acquires a sharp and definite image of the whole thing, which, like an abstract idea, includes in itself the entire essence of the substance or phenomenon. A blue, black, or yellow color, or the existence of a white precipitate which is soluble or insoluble in a certain acid or alkali, calls up in the mind of the chemist the idea of iron, iodine, kali, magnesia, sulphuric or muriatic acid, &c., an ideal iron, iodine, &c., altogether different from the conception which men in ordinary life connect with those substances.

The understanding arrives, through the combination of exact ideas, at conclusions whose truth is only intellectually discernible; the mental combinations of the artificer, on the other hand, are material or capable of being represented to the senses.

In this peculiar mental process, in which the imaginative power plays the principal part, consists essentially the idea which I should be disposed to connect with the word *induction*, and I do not think that it is in conflict with that of Aristotle.

It is not easy to convey a clear idea of the nature of the mental operations of the experimental artificer, which, as already said, depend on a combination of facts or phenomena standing in a similar relation to one another, with the logical ideas which guide the understanding in its conclusions; from the facts or reactions known to him he determines respecting the existence of a new one before unknown; his conclusion is again a fact or a reaction; perhaps it is to the peculiar faculty of the musical composer, who thinks in sounds, that the process of chemical or physical thinking may be most closely compared.

In exact research, the logic of the explanation of a phenomenon or demonstration of a problem, rests on facts, which hang together as by the links of a chain, or as by hinges, and whoever will take the trouble to revise a chemical or physical investigation, will at once perceive that a majority of the facts which serve the philosophic inquirer for an explanation or demonstration, do not offer themselves in nature, but that they are first excogitated or devised by the inquirer himself; he is necessitated to seek out the facts which are wanting to his mental oper-

ation or deduction by means of induction, that is, through the combination of his conceptive or imaginative faculty; and his labor consists in this, that, in conformity with the rules of experimental art, he shall call into action the mediums or the substances which seem adapted to his purpose, and from the reactions or phenomena which come to light, draw a conclusion as to the existence or non-existence of the fact sought for; he contrives, it may be said, a series of trials, which, in their final result, give the direction to his deduction.

The difficulty lies for him herein, that the route to the fact he is seeking is to him completely unknown; for were it known, the conclusions of the understanding would lend themselves to his aid. He is, therefore, necessitated to abide entirely by the phenomena which his tentatives furnish him, since these are the characters which guide his imaginative power in its combinations.

The remarkable discovery of ozonized oxygen in a chemical way by Schönbein, affords one of the simplest examples of inductive processes. Schönbein had found that, by the transmission of electrical sparks, the atmospheric air acquires new properties, of which the most remarkable consists in a powerful combination faculty of its oxygen, till then unknown; in such air a number of bodies (silver, for instance) are oxydized, on which the oxygen in air not electrified is without any influence. Now, how came Schönbein to conclude thereupon, that phosphorus, by being slowly burned in air, would bring about the same condition in the air as did the electric spark? This conclusion was based upon the fact that the air after electrification and after contact with phosphorus smelled precisely alike; the scenting principle in the air, at the same time, had been found by Schönbein to produce the same effects. The similarity of a sensible property, of a scent, led therefore to the inference of the origin and existence of a like substance, ozone, in two processes in their nature entirely different. In this combination of ideas, had the guidance been left to the understanding, it is highly probable that the discovery would have been impeded by it; for to the understanding the fact of the origin of a substance endued with the highest oxydizing powers, through or near a body which, like phosphorus, is in the highest degree oxydizable, would have appeared wholly improbable.

One of the most important of Faraday's discoveries furnishes an example of a more complex induction.

Oersted had, through an electrical current, induced magnetism in metallic conductors; the problem which Faraday proposed to himself was, the reverse, to generate by means of a magnet an electrical current; it was directed to the production of a phenomenon, and since its law and the way to its discovery were unknown, could only be solved in the experimental, that is, in the inductive manner. The phenomenon once known in all its relations, could then first become the subject of a deductive scrutiny, and the contrast of the inductive labor of Faraday

and the deductive labor of Weber is here quite apparent. Faraday sought, if we may use the expression, the *thing;* Weber the *principle* or the *law.* I have heard mathematical physicists regret that Faraday's treatises on such subjects were, in point of style, nearly unintelligible and scarcely readable, and that their tenor much resembled an extract from a day-book; but the fault was in themselves. Upon physicists who have advanced by the way of chemistry to physics, Faraday's treatises make much the impression of wonderfully fine music.

The discovery of the electrical machine, the electrophore, the Leyden jar, the voltaic pile, as well as of the three laws of Kepler, has been achieved through the combinations of the imaginative power; and so it is also with the procedures for the extraction of metals, which, as that of iron from iron-stone, of silver from the lead ores, and of copper from the copper ores, are among the most complicated of processes. The conversion of iron into steel, of copper into brass, the transformation of hide into leather, of fat into soap, of common salt into soda, and a thousand similar important inventions, have been made by men who had no idea, or a wholly false one, of the proper nature of the things or processes to which they directed their powers of ideal combination.

The understanding has not the least to do with the combinations of ideas which have carried the manufacturer of glove leather to the towers of the city in order to collect for his purposes the white excrement of daws and rooks, or which have led the dyer to employ that of the cow for fixing on stuffs his mordants and colors, or which, on the lofty plains of America, so poor in combustible material, prompted the miner to the singular expedient of obtaining silver in the wet way. All this will undoubtedly appear remarkable enough when it is remembered that until a few years past, the proper nature of glass, soap, and leather was unknown, and that researches are still daily made to determine precisely the reactions which take place in the melting-oven during the soda process.

As a last example of the inductive procedure in technical processes I will select the lately discovered art of producing light-images—processes, however, which have not yet found an explanation. The facts which lie at the foundation of photography are two: The one that the salts of silver (the chlorine, bromine, iodine of silver) are rendered black by the light; the other that the unblackened combinations of silver are soluble in sub-sulphurated natron, so that the blackened and the unblackened may be separated from one another by means of this salt.

These two facts formed the starting point of the experiments of Daguerre in Paris and of Talbot in London; the first sought to produce images on silvered copper-plates, the other on paper. When, in the camera obscura, an image of a tower or of a house, for instance, is thrown on paper overspread or saturated with chlorine or iodine of silver, there arises in Talbot's experiments, after some hours' exposure to the operation of the light, a corresponding image; the more lustrous

places become, in proportion to the strength of the light, blackened into corresponding shadows; the obscure places remain white or luminous. The sashes of a window, for instance, throw less light on the paper than the glass panes; a dark stone less than the bright stones. Whatever is dark in the object appears bright; the bright, dark. There is impressed on the paper a so-called negative image. If the paper be now washed with a solution of sub-sulphurated natron, so much of the chloride of silver as is unchanged by the light is removed; had this remained on the paper the image would by degrees become black, under the operation of the light, and again disappear. The salt mentioned is therefore the medium through which it becomes fixed.

The first images presented by Talbot were very imperfect; as their production required a long exposure to the operation of the light, only the images of perfectly immovable objects could be obtained. The experiments of Daguerre gave occasion to the perfecting of Talbot's procedure, but in a singular manner. Daguerre exposed his silvered plates to the influence of the vapor of iodine, and in this way gave them an extremely thin coating of silver of iodine; but from this resulted no image in the camera obscura. Months of trials, varied in all manner of ways, afforded no results. At length hazard, in the most proper sense, came to his aid; Daguerre had put aside a number of the plates which had served for his experiments in an old press, where they remained for weeks without further attention. Happening on some occasion to take one of them out, he saw, to his utmost surprise, an image traced upon it, of the greatest distinctness to the minutest particulars. No idea had he how it was produced, but, of course, there must be something in the press which had brought to light the image on the plate. Now, there were all sorts of things therein: Utensils, apparatus, chemical reagents, and, among the rest, a vessel containing quicksilver. Daguerre proceeded to remove one article after another, overlooking, however, the quicksilver; and he still procured images whenever he allowed one of the plates, on which he had thrown an image in the camera obscura, to remain some two hours in the press. Of the quicksilver he did not think; the old press had begun to appear to him an enchanted press. At last it occurred to him that the image must proceed from the quicksilver, and it turned out to be what may be called a breath picture. If a drawing be made with a wooden pencil on a clean glass plate, the sharpest sight will fail to discover the lines, which nevertheless become distinguishable when the places marked by the pencil are breathed upon. There exists, in effect, in these places and other parts of the glass an unequal condensation of the watery vapor which is deposited thereon in fine drops.

In this manner Daguerre's images originated. Quicksilver is volatile, and its vapor had been diffused through the press and settled in minute drops on the plates, taking effect more strongly on the more illuminated parts, so that the outlines and shadings of all objects were rendered

clearly visible. I do not propose to enter here into the improvement of the optical apparatus, nor to explain how the fugitive images of Daguerre were, by gilding in a chemical way, rendered stable and unalterable, but I return to the images on paper and will first speak of the influence which the Daguerrean discoveries had upon Talbot's undertaking.

Daguerre had found that the effect of the light exerted for a second on his prepared plates sufficed, through evaporization with quicksilver, to bring out an image. As Talbot had on his paper the same preparation as Daguerre on his plates, he inferred that on the paper also, by a second's illumination in the camera obscura, the sun must have produced an impression; he was convinced that an image was present on the paper, though not a trace of it was to be seen. This conviction impelled him to seek for some medium through which the figure might be brought out; there must be something, he thought, by which this could be effected. Now, how came Talbot to employ a solution of gallic acid for this purpose?

Most persons, perhaps, would be disposed to allege here, as in Daguerre's case, the intervention of hazard, but the choice of gallic acid was no accident. Daguerre had placed the vessel containing quicksilver in the press with no view to experiments; his images were produced through no agency of his. Talbot, on the other hand, applied himself to the research for means of accomplishing a definite object, and among so many thousand substances his imaginative faculty naturally rejected all those which stood in no relation to that object, and dwelt only on those which produce an effect similar to that of light. Now, light and warm gallic acid blacken the salts of silver; the effect of both is identical, but that of gallic acid much the stronger. The sun's light had, in the camera obscura, produced an effect on the prepared paper, but one too weak to be perceptible; perhaps it might, as he argued, be brought out and strengthened by gallic acid. The trial succeeded, and the correctness of the induction was thereby vindicated.

From these examples the nature of induction ought to be intelligible to every one. It will be remarked that an acquaintance with the principle of the processes, *how* light and gallic acid properly act upon the salts of silver, *whereon* the solution of these salts in sub-sulphurated natron depends, was for Talbot's as well as for Daguerre's purpose perfectly indifferent.

For those persons who have no acquaintance with the ideal combinations of the imaginative power, they naturally do not exist, and such are for the most part prone to ascribe to chance discoveries which proceed from the most sagacious inferences of the faculty. Chance has indeed its own part therein, since the elements for the determinations of the understanding are so frequently offered to it by so-called accidental circumstances. But the fact that experimentation must be learned; that it has its rules and is an art, and that their results presuppose a very widely ranging acquaintanceship with facts or sensible phenomena,

teaches us that it rests on a properly intellectual labor, in which the understanding participates as a useful counsellor and assistant, but without guiding it and without its being dependent thereupon.

In science, as well as in common life, the operations of the mind are executed not according to the rules of logic, but the conception of a truth, the idea of a process or the cause of a phenomenon, generally precedes the demonstration; the conclusion is not reached through the premises, but the conclusion goes before, and the premises are then first sought out as proof. In a conversation with a celebrated French mathematician, on the part which the imaginative faculty bears in scientific labors, he expressed himself to the effect that by far the greater number of mathematical truths are obtained, not by deduction, but through the inventive or imaginative power, and in this he had a view even to the properties of the triangle, the ellipsis, &c., which is saying little else than that the mathematician, as well as the physicist, can do nothing for his science without artistic endowment.

It is scarcely necessary to say that for deductive as well as inductive research, if any results are to follow, a certain extent of information is prerequisite; for the deductive research, a well-grounded knowledge of laws already discovered, to which previous reading and books are contributary; for inductive, a comprehensive acquaintance with material phenomena which is to be acquired in chemical, physical, and physiological laboratories. As schools, these last are a modern creation, and their influence in the development of all departments of physical science is, to the reflecting observer, a thing not to be questioned.

To an acquaintance with sensible phenomena or the knowledge of the nature and action of things, must be united in the case of the inductive inquirer, if he would duly resolve the problems presented to him, a memory for sensible phenomena, a memory, it might be said, of sight, taste, and smell, together with a certain degree of artistic expertness and dexterity. The broader and more comprehensive his knowledge of facts and phenomena, or, as it is usual to say, the greater his experience, so much the more will his labor be lightened; an experienced man makes much fewer experiments than the inexperienced, who must make himself acquainted with many phenomena which to the other are already familiar; to the former, indeed, for the attainment of many ends, numerous experiments would be superfluous, since the combination of processes and facts already within his knowledge, abundantly suffices.

In the solution of their respective problems, the deductive and inductive inquirer begin in the same manner; the one, like the other, starts from a complex idea of the understanding or the imaginative power, of which in general only a part is true, while the other parts rest on erroneous inferences or combinations. The deductive inquirer tests and experiments with intellectual conceptions in order to find the truth, just as the inductive inquirer does with sensible ideas in order to find the thing sought for; both, in the prosecution of their inquiries, strip away,

by testing and improving, what is false, and detect the parts which are wanting to complete the idea submitted to examination. The idea from which they set out is not unfrequently wholly false, and the true is first sprung in the course of the investigation. Hence, the doctrine of many of the greatest inquirers that the labor is everything, and that any theory may lead to truth, provided it gives the impulse to toil.

In deductive inquiry, it is the conviction of the correctness of a concluding idea (*schluss-idee*) which stimulates the understanding of the inquirer to its appropriate activity; and so with the experimental artificer, the conviction of the existence of a thing is the first and most efficacious incitement to the movements of the imaginative power; the discovery of a new fact or reaction, to which the idea of something before unknown, something useful or important for industry or life, attaches, is sufficient to awaken the conviction of its existence in many individuals, and it not unfrequently happens that it is in reality simultaneously discovered by several.

Understanding and imagination are alike necessary to our knowledge, and in science are alike authorized; they both have an allotted part in all problems of physics and chemistry, of medicine, of public economy, history and philology, and comprise each a certain space in its appropriate province. The part in which the imaginative faculty bears sway is proportionately wider and more comprehensive, as the positive knowledge with which the understanding circumscribes it is more indeterminate and indistinct. Progress consists in this, that with the increase of knowledge, the conceptions which have sprung from the imagination vanish, and while in the first periods of science this faculty had undisputed ascendancy, at a later stage it subordinates itself to the understanding and becomes to the latter a helpful and willing servant.

Induction under the guidance of the imagination is intuitive and creative, but vague and extravagant; deduction under the guidance of the understanding analyzes and limits, and is definite and measurable.

One of the most essential characters of deductive inquiry in science is *measure*, and the ultimate aim of all its labors is directed to an unalterable numerical expression for the properties of things, for processes and phenomena. Imagination compares and discriminates, but measures not, for measurement implies a scale, and that is a product of the understanding.

By the introduction of science into an art accrues an advantage, scarcely enough appreciated; that science abolishes art as such, and what is individual in it, while resolving it into rules which may be taught and learned; through a knowledge of which rules even the unproficient in business, industry, husbandry, and technics, is invested with the power of the most proficient, most skillful, and most experienced practitioner, who attains his aims by the shortest, surest, and most economical means. What before was proper to the individual bebecomes thenceforth the joint property of all.

ADDRESS ON THE RELATION OF FOOD TO WORK, AND ITS BEARING ON MEDICAL PRACTICE.

By Rev. Samuel Haughton, of Dublin.

Mr. President and Gentlemen: Man, like other animals, is born, grows, comes to maturity, reproduces his like, and dies, passing in his lifetime through a cycle of changes that may be compared to a secular variation, by a metaphor borrowed from the science of astronomy; while in his daily life he passes through a smaller cycle of changes that may be called periodic.

From the time of the publication of Bichat's celebrated Essay on Life and Death, it has been admitted that man and other animals possess a double life, animal and organic, presided over, respectively, by two distinct though correlated centers of nervous force; of these, one thinks, moves, and feels; the other merely cooks, receiving the food supplied, changing and elaborating it into elements suitable for the use of the animal life. In the lower forms of animals the organic life becomes almost coextensive with the whole being of the creature, which simply digests, assimilates, and excretes, but barely feels or moves; in the higher forms of animals, and more especially in man, the animal life dominates over the organic life, which becomes its slave, and exhibits the remarkable phenomena of mechanical force, of geometrical instinct, of animal cunning, and, finally, in man himself, produces intellectual work, rising to its highest form in the religious feeling that recognizes its great Creator, and bows in humility before Him. It is a simple matter of fact, and of every-day observation, that all these forms of animal work are the result of the reception and assimilation of a few cubic feet of oxygen, a few ounces of water, of starch, of fat, and of flesh.

The general question of the relation of food to work would involve a consideration of the possibility of throwing a bridge across the gulf that separates the organic from the animal life, so as to connect the products of nutrition (taken in its widest sense) with the work of every kind accomplished by the animal life, whether mechanical or intellectual. We resemble the spiders of the heather on a summer morning, that float their gossamer threads into the air from the summit of a branch, in the hope that some stray breath of wind may fasten them to a neighboring tuft, and enable the hungry speculator to extend the range of his rambles and his chance of food. Already a few feeble threads connect the chemistry of our food with the mechanical work done by our muscles; when these shall have been securely fastened, from the higher vantage

ground thus acquired, our little bridge of knowledge may possibly be extended to embrace the phenomena of the geometrical instinct of the bee, or the cunning of the beaver, and our successors may even dare to speculate on the changes that converted a crust of bread or a bottle of wine, in the brain of Swift, Molière, or Shakespeare, into the conception of the gentle Glumdalclitch, the rascally Sganarelle, or the immortal Falstaff. At present such thoughts would be justly regarded as the dreams of a lunatic, and I must crave your indulgence for having mentioned them. The history of science is, however, filled with such dreams—some never realized, others converted by time into realities so commonplace that the genius of their originators is habitually forgotten or underrated.

During childhood and youth the food that we eat is used for the double purpose of building up the tissues of the bones, muscles, brain, and other organs of the body, and of supplying the force necessary for work done, whether mechanical or intellectual. In adult life the first use of food almost disappears, for the bones, muscles, brain, and other organs have already reached their full development, and act simply as the media of communication between the food received and the work developed by it.

Let us take, as illustrations, the muscles and brain, regarded as the organs by means of which mechanical and intellectual work is done. These organs resemble the piston, beam, and fly-wheel of the steam-engine, and, like them, only transmit or store up the force communicated by the steam in one case, and by the products of the food conveyed by the blood in the other case. The mechanical work done by the steam-engine must be measured by the loss of heat experienced by the steam in passing from the boiler, through the cylinder, to the condenser, and not by the loss of substance undergone by the several parts of the machinery on which it acts. In like manner, the mechanical or intellectual work done by the food we eat is to be measured, not by the change of substance of the muscles or brain employed as the agents of that work, but simply by the changes in the blood that supplies these organs, that is to say, undergone by the food used in its passage through the various tissues of the body, before it is finally discharged in the form of water, carbonic acid, or urea.

The Divine Architect has so framed the animal machine, that moves and thinks, that the same blood which, by its chemical changes, produces movement and thought, also repairs the necessary waste of the muscles and brain, by means of which movement and thought are possible; just as if the steam that works an engine were able, without the aid of the engineer, to repair the wear and tear of its friction and waste spontaneously; but no greater mistake is possible in physiology than to suppose that the products of the changes in the blood by which mechanical or intellectual work is done are themselves merely the

result of the waste of the organs, whether muscles or brain, on the exercise of which that work depends.*

The ancients, who derived all their knowledge from observation, and not from experiment, were well aware of the double duty imposed upon food in early life—of producing both the secular and the periodic variations of the body, or, in other words, of promoting growth, and of developing work. Their practical knowledge is summed up by Hippocrates in the aphorism, "Old men bear want of food best; next those that are adults. Youths bear it least, more especially children, and of these the most lively are the least capable of enduring it."

The food consumed in twenty-four hours, including air and water, undergoes a series of changes of a chemical character before leaving the body, in the form of one or other of its excretions. Some of these changes develop force, and others expend force, but the algebraic sum of all the gains and losses of force represents the quantity available for work. This work must be expended as follows:

1. The work of growth, (*secular.*)
2. The work of maintaining heat, (*periodic.*)
3. Mechanical work, (*periodic.*)
4. Vital work, (*periodic.*)

During childhood and youth the work of growth is positive, for a certain proportion of the food used is employed in building up the tissues of the body instead of being expended in actual work; it is, in fact, "stored up" in the body, as *vis viva* is stored up by the fly-wheel of machinery, and constitutes a reservoir of force that may be called upon at an emergency requiring sudden expenditure of force, as in case of illness, or to supply the gradual wasting of old age. In adult life and in old age, the work of growth ceases completely, except so far as is necessary to repair, from day to day, the small wastes of the organs employed in work; so that nearly the whole of the food employed is expended on the periodic work of the body. Hence we can readily see the reason for the aphorism which asserts that food is more necessary for the young than for the old, and more required by those of a lively disposition, either of mind or body, than by others.

* The very skill with which provision is made for the repair of the waste of the organ used as the instrument of work may mislead the observer into supposing that the work itself may be measured by the waste of its instrument. Thus, it has been shown by Mr. A. Macalister, of Dublin, that the heart, which has imposed upon it the necessity of working day and night without ceasing, during life, is furnished with double the usual supply of blood through the coronary arteries, which are injected twice for every single beat of the heart. If, indeed, it were possible to assume that all muscles wasted equally for equal quantities of work, and also to measure separately the products of that waste, we might then assume the waste of the organ as the measure of its work. Neither of these assumptions, however, can be admitted, for it can be shown that different muscles act under different conditions more or less advantageously, so that equal wastes would represent unequal works; and, also, it is impossible to separate in practice the products of waste of muscles from those of the general changes of the blood.

HIPPOCRATIC DOCTRINE OF INNATE HEAT.

Hippocrates was well aware of the connection between food and animal heat, although he erroneously regarded the animal heat as an innate property of the body that caused an appetite for food, instead of being itself produced by food; if we transpose his cause and effect, *mutatis mutandis*, all his maxims as to animal heat are true. Thus, he says:

"Growing animals possess most innate heat, hence they require most food; . . . . . but the old have least heat, and therefore require the least fuel."

"The cavities of the body are naturally warmest in winter and spring; . . . . . in these seasons therefore most food must be given; and since there is more innate heat, more nourishment is required; as may be seen in youths and athletes."

These maxims, when translated into modern language, express the well-known fact that the chemical changes of food that take place in the body produce animal heat, and that the necessity for food to supply mechanical work is greatest with the young and active, while the necessity for the production of animal heat is greatest in the cold seasons of the year. The direct connection of food with mechanical work is expressed in the following maxims:

"There should be no labor when there is hunger;" and its converse, "Let labor precede meals."

On principles such as those just given, the training of the athletes was conducted; and they were compelled to undergo a regular course, commencing with blood-letting and active purgation, and consisting of systematic muscular exercise suited to the nature of the contest intended, accompanied by a dietary, of which the chief ingredients consisted of biscuits and pigs' kidneys, washed down by a minimum of water. It is truly not much to be wondered at that those who survived the training were formidable in the boxing-ring or race-course.

The relation of animal heat to respiration is referred to by Hippocrates in a remarkable maxim:

"Those persons have the loudest voices who have most [innate] heat, for they inspire the largest quantities of the cold air; and the product of two great quantities must be itself great."

Galen believed the heart to be the center of "innate heat," but he was well aware that increase or diminution of respiration caused increase or diminution of heat, and was intimately connected with it. Thus he says:

"Since, therefore, the heart is, as it were, the hearth and fountain of the innate heat with which the animal is pervaded," &c.

"The necessity for respiration is the greatest and most imperious guard of the innate heat."

"Those persons in whom the innate heat has been much cooled breathe but little and slowly."

LAVOISIER'S THEORY OF ANIMAL HEAT.

The doctrine of "innate" heat, taught by Hippocrates and Galen, ruled in medicine for fifteen hundred years after Galen's death, until it received its death-blow from the genius of Lavoisier, who demonstrated in his celebrated memoir read before the French Academy of Sciences in 1783, that the source of animal heat is to be found in the combustion of the carbon of the body by the oxygen of the air received into the lungs by respiration. Lavoisier's experiments were repeated and confirmed in 1822 by Dulong and Despretz, and have formed the starting-point for all modern investigations on the relation of food to work. As already stated, the work done by food in the body may be divided into—

1. The work of growth.
2. The work of animal heat.
3. Mechanical work.
4. Vital work.

Lavoisier arranged his experiments so as to exclude almost all the foregoing kinds of work except that of animal heat. A Guinea pig was placed under a bell-glass inverted over a surface of mercury, and a current of fresh air was allowed to circulate through the apparatus, being passed at its final exit through tubes containing caustic potash, which arrested the carbonic acid produced by the animal. In this manner it was easy to ascertain the carbonic acid excreted by the increase in weight of the tubes of caustic potash during the experiment.

Lavoisier found that his Guinea pig, in ten hours, burned, on the average, 3.333 grams of carbon; and this quantity of carbon he estimated, from other experiments, as capable of melting 326.75 grams of ice at the freezing temperature. The same Guinea pig was then placed in an ice-calorimeter, and left in it for ten hours, during which time the heat of its body was found to have melted 402.27 grams of ice at the freezing temperature.

If we use, instead of the coefficient of combustion of carbon employed by Lavoisier, that now generally adopted from the experiments of Favre and Silbermann, the quantity of melted ice represented by $3\frac{1}{3}$ grams of carbon would become 364.78 grams instead of 326.75 grams. We are, therefore, entitled to say that the heat of combustion of expired carbon determined by Lavoisier is equal to

$$\frac{36478}{402.27} = 90.68 \text{ per cent.}$$

of the animal heat developed, which is regarded as 100 parts.

Two years later, in 1785, Lavoisier laid before the Royal Society of Medicine of Paris, an account of further experiments, also conducted on the breathing of Guinea pigs, by which he showed that of 100 parts of oxygen absorbed by those animals, 81 only reappeared in the form of carbonic acid, and 19 parts disappeared altogether. Lavoisier considered that these 19 parts of oxygen were employed in the body in the combustion of hydrogen, the product of such combustion being water.

If we use Lavoisier's data just given, and the known atomic weights of carbon, oxygen, and hydrogen, we shall have, for 81 parts of oxygen in the form of carbonic acid, and 19 parts of oxygen in the form of water, the following quantities of carbon and hydrogen consumed by the respiration of his Guinea pig in the same time:

$$\text{Carbon} = \frac{6 \times 81}{16}; \ \text{hydrogen} = \frac{19}{8}$$

Multiplying these numbers by the heat-coefficients of Favre and Silbermann, we find—

$$\text{Heat produced by carbon} = \frac{6 \times 81}{16} \times 8080$$

$$\text{Heat produced by hydrogen} = \frac{19}{8} \times 34462$$

It has been already shown that the heat developed by the combustion of carbon in Lavoisier's experiment amounted to 90.68 per cent. of the heat emitted by the animal; hence the heat produced by the combustion of the hydrogen will amount to—

$$90.68 \times \frac{19 \times 34462}{8} \times \frac{16}{6 \times 81 \times 8080} = 30.24$$

By adding together the heats due to the carbon and hydrogen, we find that Lavoisier's experiments, when fairly interpreted by the data of modern science, give the following results:

Heat produced by the combustion of carbon and hydrogen....	120.92
Animal heat	100.00

Finally, in 1789, Lavoisier published further experiments, by which he showed conclusively that the consumption of oxygen by the body is notably increased by three causes—

1. By a lowering of the external temperature.
2. By the act of digestion.
3. By muscular exercise.

The experiments of Lavoisier were repeated in 1822 by Dulong and Despretz, and their results, when corrected, like those of Lavoisier, by using the modern heat-coefficients of carbon and hydrogen, are as follows:

The mean of Dulong's experiments on sixteen animals and birds is 90.6 per cent. of the animal heat given out; the lowest number, 85.5, belonging to a kitten sixty days old; and the highest number, 99.4, belonging to a puppy fifty days old.

M. Despretz obtained an average of 92.3 from sixteen mammals and birds; his highest number being 101.8, derived from an old female rabbit; and his lowest number being 84.2, derived from four owls.

The foregoing experiments left no doubt remaining in the minds of men of science as to the substantial truth of Lavoisier's doctrine of animal heat; and led immediately to a number of supplementary experiments, among the most remarkable of which were those of Regnault and Reiset.

Regnault directed his attention especially to the distribution of the oxygen absorbed by animals, between the carbon and hydrogen of their blood or tissues, which had been laid down by Lavoisier in the proportion of 81 to 19. He found that the proportion was not a fixed one, but varied with the food in a very instructive manner.

The average of his experiments on fourteen animals, including worms, lizards, and insects, as well as birds and mammals, was—

Oxygen combined with carbon	81.7
Oxygen combined with hydrogen..................	19.3

a result nearly identical with that found by Lavoisier. The highest proportion of oxygen combined with hydrogen occurred in the case of chickens fed on meat, and amounted to 32 per cent.; and the lowest proportion occurred in the case of rabbits fed on bread and oats, and amounted to 1 per cent. only.

Still more recent experiments, made with improved apparatus and methods by Pettenkofer and Voit, in Munich, show, like those of Regnault, that the proportion of the oxygen employed in forming carbonic acid to the whole oxygen absorbed varies with the food, ranging in the case of a large dog from 52.4 to 148.2, according as the animal was kept altogether without food, or fed upon a mixed diet of meat and sugar. These investigations have also shown that, under ordinary conditions, it is probable that a dog consumes nearly all the oxygen absorbed in the formation of carbonic acid.

Before leaving the subject of animal heat, it is worth while to estimate its amount in a manner that will bring it into comparison with ordinary mechanical work.

In Lavoisier's experiment with the Guinea pig, 402.27 grams of ice were melted in ten hours; from this fact we find, assuming the latent heat of ice at 142° F., and 772 as Joule's coefficient for converting British heat-units into foot-pounds,

Mechanical work-equivalent to the daily animal heat of Lavoisier's Guinea pig =

$$\frac{402.27 \times 24 \times 142 \times 15.432 \times 772}{7000 \times 10} = 233310 \text{ foot-pounds.}$$

As the average weight of a Guinea pig is four pounds, the preceding amount of work, representing animal heat, would be sufficient to raise the weight of the animal through a vertical height of—

$$\frac{233310}{4 \times 5280} = 11.05 \text{ miles.}$$

Ranke has shown, by experiments made upon himself, under various conditions of food and fasting, by means of Pettenkofer and Voit's apparatus, that his daily excretion of carbonic acid varied from 660 grams to 860 grams, showing a mean of 760 grams. His weight was 67 kilograms, from which fact, and the assumption that an English mile is 1,600 meters, we obtain, employing the constants already given, the height through

which the combustion of 760 grams of carbonic acid would raise the weight of 67 kilograms in 24 hours—

$$= \frac{760 \times 6 \times 8.080 \times 423}{22 \times 67 \times 1600} = 6.609 \text{ miles.}$$

The extreme values of the carbonic acid excreted, viz, 660 grams and 860 grams, would correspond to the heights of 5.74 miles and 7.48 miles, respectively.

Dr. Edward Smith has estimated the daily excretion of carbon from the lungs, in the case of four persons, as follows:

	Body weight.	Carbon.
Mr. Moul	173 pounds.	6.735 ounces.
Dr. E. Smith	196 pounds.	7.85 ounces.
Prof. Frankland	136 pounds.	5.60 ounces.
Dr. Murie	133 pounds.	6.54 ounces.

In order to convert the preceding data into vertical miles through which the body weignt is lifted, we must multiply the ounces of carbon by the following coefficient, and divide the product by the body weight:

$$\text{Coeff.} = \frac{8080 \times 9 \times 772}{16 \times 5 \times 5280} = 132.91$$

$$\log(\text{coeff.}) = 2.1235473$$

We thus obtain, for the heights through which the carbon consumed would lift the observers—

Mr. Moul	5.17 miles.
Dr. E. Smith	5.32 miles.
Prof. Frankland	5.47 miles.
Dr. Murie	6.53 miles.

Pettenkofer and Voit succeeded in producing a range of carbonic acid excreted by a large dog, weighing 33.3 kilograms, from 289.4 grams to 840.4 grams; the minimum corresponding to the 10th day of fasting from solid food, and the maximum corresponding to a diet of 1,800 grams of meat, 350 grams of fat, and 1,410 grams of water.

It may be easily shown, by a calculation similar to the foregoing, that these excretions of carbonic acid correspond to the mechanical works of lifting the weight of the dog through vertical heights of 5.03 miles and 14.62 miles, respectively.

Combining together the preceding results, and expressing them all in the natural units of the weights of the animals lifted through a height, we find—

Work due to animal heat.

MAN.

1. Dr. Ranke, (fasting)	5.74 miles.
2. Dr. Ranke, (well fed)	7.48 miles.
3. Mr. Moul	5.17 miles.

4. Dr. E. Smith	5.32 miles.
5. Prof. Frankland	5.47 miles.
6. Dr. Murie	6.53 miles.
Mean	5.952 miles.

This result agrees very closely with the calculation already made from 760 grams of carbonic acid, in the case of Dr. Ranke, viz, 6.609 miles.

Work due to animal heat.

ANIMALS.

1. Guinea pig	11.05 miles.
2. Dog, (fasting)	5.03 miles.
3. Dog, (overfed)	14.62 miles.
Mean	10.233 miles.

SOURCE OF MUSCULAR WORK.

As soon as it was satisfactorily established by Lavoisier and his successors that the natural combustion of carbon and hydrogen in the blood was sufficient, or somewhat more than sufficient, to account for the animal heat, it became a matter of great interest to physiologists to ascertain, if possible, how much of the work developed in the blood by chemical changes is employed in producing animal heat, how much in mechanical work, external and internal, and how much in vital or mental operations.

At the outset of this inquiry, it received a misdirection from the conjecture thrown out by Liebig, that the excretion of nitrogen (in the form of urea) gave necessarily the measure of the wear and tear of the muscular tissues themselves, which are composed of proteinic or nitrogenous compounds. This conjecture led to Liebig's celebrated classification of food into heat-producing and flesh-forming foods, which has been unhesitatingly received until lately, in this country, by physiologists and physicians. Before investigating the truth or falsehood of Liebig's theory, it is worth while to state the most recent results obtained as to the muscular work per day of which man is capable.

From numerous observations, of which some were made by myself, on the daily labor of hodmen, paviors, navvies, and pedlars, I have obtained the following mean:

Daily labor of man = 353.75 foot-tons = 109549 kilometers.

This quantity of work is the exact equivalent of the work done by a man of 150 pounds weight in climbing through one mile of vertical height, and is, as I have already shown, about one-sixth part of the work expended in producing and maintaining animal heat.

I was led to believe, from investigations made to determine the quan-

tity of urea excreted in various diseases, that a certain minimum quantity, equivalent to 2 grains per pound of body weight, was excreted quite independently of muscular exertion, and I proved that death was preceded in many chronic diseases by a fall in the urea excreted to 2 grains per pound. These investigations were made chiefly on patients dying of advanced kidney disease, in which the excretion of albumen had nearly or altogether ceased, and of patients dying of phthisis.

Pettenkofer and Voit found that the excretion of urea in a dog reduced from 33.3 kilograms to 29 kilograms by 10 days' fast, became 8.6 grams. And, since—

29 kilograms = 63.8 pounds.
8.6 grams = 132.7 grains.

Excretion of urea = 2.08 grains per pound of body weight.

Ranke obtained a precisely similar result from observations made upon himself, after long fasting, continued for several days.

If these views be well founded, it is plain that part only of the urea excreted can be regarded as due to muscular exertion, for 2 grains per pound (or 300 grains for a man weighing 150 pounds) must be set aside as a constant due to vital work, independent of muscular work altogether. Hence it would follow, supposing the muscular exertion to be measured by the increased excretion of urea produced by it, that the urea will not increase as fast as the muscular exertion, but it ought to increase regularly, although at a slower rate. With a view to settle this important question, I devised the following observations upon myself in the month of July, 1866, which prove conclusively that an increase of muscular exertion, amounting to fourfold, is not accompanied by any corresponding increase in the excretion of nitrogen in the form of urea.

I had previously ascertained by repeated experiments, extending from 1860 to 1865, that my excretion of urea (under ordinary conditions as to exercise, which never amounted to five miles per day) ranged from—

465.09 grains per day, to
537.47 grains per day.

501.28 mean.

This quantity of urea I regarded as my natural physiological average, and it was so well established that I thought I should obtain an important result by comparing it with the average found from several days of unusual muscular exertion. I accordingly walked for five consecutive days in the hilly districts of Wicklow, noting carefully the horizontal distance traveled each day, and the vertical height traversed up and down. The vertical heights were reduced to horizontal distances, on the assumptions (which are well founded) that 20 is the proper coefficient for converting one into the other, and that the work of descent is half the work of ascent.

During the five days of observation the work done, expressed in horizontal miles of walking, was as follows:

First day.

		Miles.
Miles walked		11.4
Height ascended	1,800 feet =	10.2
		21.6

Second day.

Miles walked		12.0
Height ascended	2,400 feet =	13.7
		25.7

Third day.

Miles walked		11.6
Height ascended	1,400 feet =	8.0
		19.6

Fourth day.

Miles walked		9.3
Height ascended	1,400 feet =	8.0
		17.3

Fifth day.

Miles walked		10.4
Height ascended	1,600 feet =	9.1
		19.5

From the preceding statement it follows that the average work done each day was 20.74 miles of horizontal walking, the result of which upon the urea excreted was to be compared with the result already mentioned as a physiological constant, determined under circumstances in which the daily muscular work never exceeded five miles of horizontal walking.

In order to determine the urea, I collected each day all the urine passed, and kept one-fifth part of it; and at the close of the fifth day examined the mixture formed from the five days' urine. It was found to contain 501.16 grains of urea per day—a result practically identical with the physiological quantity previously found by me under totally different conditions, viz, 501.28 grains. I was much surprised at this result, for I had previously believed in the theory laid down by Liebig, which attributed the excretion of urea to the disintegration of muscular tissue.

It might be objected to the preceding reasoning that the combustion of proteinic compounds represented by 501.28 grains of urea excreted is

actually sufficient to produce the mechanical force necessary to maintain the muscular exertion of walking 20 or 21 miles per day.

1. The urea excreted bears to the proteine consumed the proportion of 24 to 79, as appears from their chemical compositions, viz:

Urea	$C_2\ H_4\ N_2\ O_2$	60
Proteine	$C_{36}\ H_{27}\ N_4\ O_{12}$	395

2. In 100 parts of proteine there are 53.7 parts of carbon, and 7 parts of hydrogen; the total heat due to the combustion of 1 gram of proteine is, therefore,

	Heat-units.
0. 537 gram of carbon	4. 3389
0. 070 gram of hydrogen	2. 4123
	6. 7512

This number, 6.7512, represents the maximum quantity of heat-units* that could be produced by the combustion of 1 gram of proteine; but the term depending on hydrogen in it should be reduced to five-ninths of its amount, in consequence of the hydrogen already combined with oxygen in the proteine. Hence we find—

Combustion of one gram of proteine.

	Heat-units.
Carbon	4. 3389
Hydrogen	1. 3402
	5. 6791

3. In 100 parts of urea there are 20 parts of carbon, and $6\frac{2}{3}$ parts of hydrogen; the total heat, therefore, due to the combustion of 1 gram of urea is:

	Heat-units.
0. 20 gram of carbon	1. 6160
0. 067 gram of hydrogen	2. 3089
	3. 9249

The term depending on hydrogen, in this result, should be reduced to one-half, in consequence of the hydrogen already combined with oxygen in the urea.

Hence we find—

Combustion of one gram of urea.

	Heat-units.
Carbon	1. 6160
Hydrogen	1. 1544
	2. 7704

* Heat-unit = 1 kilogram of water raised 1° C.

4. From the three preceding statements it is easy to see that, for every gram of proteine consumed, 0.8416 heat units are contained in the urea excreted; so that—

The digestion of 1 *gram of proteine gives out* 4.8375 *heat-units.*

It is easy to see that 501.28 grains of urea excreted correspond to 1,650 grains of proteine in the food, or to 106.92 grams; and the total work due to the digestion of this quantity of food may be found by multiplying it by the "*digestion coefficient*" already found, and by 423, which is Joule's coefficient for converting heat-units into kilogram-meters. Hence we have—

Work due to production of 501.28 *grains of urea*

$= 106.92 \times 4.8375 \times 423 = 218786$ kilogram-meters $= 704$ foot-tons.

This amount of theoretical work produced by nitrogenous food is double the work actually done during the walking excursion.

The average work was 20.74 miles horizontal per day, which may be considered as the exact equivalent of lifting my weight (knapsack and clothes included = 150 pounds) through one mile of vertical height. Hence the work actually done by me was—

$$\frac{150 \times 5280}{2240} = 354 \text{ foot-tons.}$$

This amount of muscular work accounted for almost exactly half the whole theoretical work supplied by the food that goes to form urea, viz, 704 foot-tons. But it has been already shown that 2 grains of urea per pound of body weight is required to maintain the vital work, including circulation and respiration; this would give (since I weighed 128 pounds) 256 grains of urea required for vital work, or almost exactly half of the 501.16 grains excreted, so that one-half of the available work might be considered as expended on vital work, and the other half as expended on external muscular work. This supposition, however, requires us to believe that the muscles act without loss by friction. This is not admissible, for I have elsewhere endeavored to show that there is a loss in the force applied by the muscles of various animals, in consequence of the friction of their tendons, amounting on the average, in man, to 35 per cent., and in the mastiff, to 41 per cent.

Hence it may be regarded as certain that the available force represented by 501 grains of urea is not sufficient to account fully both for vital work and for the external mechanical work expended by me during the experiments just described.

The foregoing observations and calculations were made in the month of July, 1866, but I did not then publish them, as I found afterward that I had been anticipated by Dr. Fick and Dr. Wislicenus, of Zurich, in a paper published in June in the Philosophical Magazine, on the urea excreted during an ascent of the Faulhorn. Professor Frankland, in a paper published in the same journal in September, 1866, corrected some erroneous reasoning that found its way into Fick and Wislicenus's paper, and further supplied, from direct experiment, the *digestion coeffi-*

cient of proteine, which had been obtained by me from calculation. The actual value of this important constant was found by him to be—

Actual value of digestion coefficient of proteine .. 4.3155
Calculated value 4.8375

My only object in now publishing an account of the independent experiment and calculation made by myself is to confirm the certainty of the important fact first proved experimentally by Fick and Wislicenus, that the force due to the urea excreted in a given time is not sufficient to provide the actual work that may be done by the muscles in the same time.

Liebig and his followers, misled by a preconception of the simplicity of nature, assigned to nitrogenous food the duty of providing the force necessary for the production of muscular work, by supplying the waste of muscular tissue; while they supposed the farinaceous and fatty foods to provide the amount of animal heat required by the body.

The opponents of Liebig have fallen into the opposite error, and deny that nitrogenous food contributes any portion of the force employed in muscular work.

The truth, as is usual, lies between the two extreme hypotheses, and we are now compelled to admit that a given development of force, expressed in animal heat, muscular work, and mental exertion, may be the effect of several, perhaps many, supposable supplies of digested food, farinaceous, saccharine, fatty, and albuminous.

Just as a given algebraical function may be equated to a given constant, by the use of a certain definite number of values of its variable quantity, so may a given effect of work in the animal body be produced by certain definite though very different combinations of various kinds of food, the digestion of which follows each its own law, and develops its own amount of force. The number of roots in our equation of life increases the difficulty of solving it, but by no means permits the acceptance of the lazy assumption that it is altogether insoluble, or reduces a sagacious guess to the level of the prophecy of a quack.

Lavoisier supposed in his earlier investigations that animal heat was developed by the combustion of carbon and hydrogen in the lungs; just as in earlier times it was supposed to be produced spontaneously in the heart, which was imagined to be so hot as even to burn the hand that should imprudently venture to touch it.

In like manner, Liebig and his followers supposed the muscular work to be developed in the substance itself of the muscles that were its instruments.

Both of these doctrines are now justly repudiated by physiologists, and the view proposed in 1845, by Dr. Mayer, of Heilbronn, and recently developed with much ability by Mr. C. W. Heaton, of Charing Cross Hospital, in the Philosophical Magazine for May, 1867, that the blood itself is the seat of all the chemical changes that develop force in the

body, has gained favor among physiological chemists, and also met with acceptance among practical clinical observers.

Thus the human mind revolves in cycles, and the physicians of the nineteenth century are preparing to sit at the feet of Moses, and learn that the blood of an animal really constitutes its life; while South African theologians are disposed to reject his authority, because he happened to confound a rodent with a ruminant.*

Whatever be the kind of food employed, its effect in the production of force must be ultimately measured by the quantities of carbonic acid and water produced by its combustion, and there is no more convenient measure of the production both of carbonic acid and water than urea, so far as it goes. I shall prove shortly that every four grains of urea excreted represent five tons lifted through one foot; and I have shown by the preceding investigation that the work represented by urea is not sufficient to account for vital and external work, much less for animal heat. The investigations of Dr. Edward Smith, on the excretion of carbonic acid, enable us to show that the carbonic acid alone is sufficient to account for both vital and external work, and also for the production of animal heat. This may be proved as follows:

Dr. Smith has given results, from which may be deduced the quantities of carbonic acid excreted per minute during the four following conditions:

1. Lying in the horizontal position, and nearly asleep.
2. Fasting, and in sitting posture.
3. Walking at two miles per hour.
4. Walking at three miles per hour.
5. Working on the tread-mill, ascending at the rate of 28.65 feet per minute.

	Carbonic acid per min.
1. Sleep and rest	5.522 grains.
2. Sitting	7.440 grains.
3. Walking at two miles per hour	18.100 grains.
4. Walking at three miles per hour	25.830 grains.
5. Tread-mill	44.973 grains.

The foregoing quantities of carbonic acid per minute may be converted into vertical miles per hour for the body weight, by multiplying them by the following coefficient:†

$$\frac{60 \times 6 \times 8080 \times 9 \times 772}{22 \times 196 \times 5280 \times 5 \times 7000} = 0.025263$$

$$\log = \bar{2}.40420$$

*No reasonable person can fail to perceive the ignorance of the great lawgiver who will apply to him the test first proposed by Swift for Homer; Moses, like the author of the Iliad, was profoundly unacquainted with the discipline and doctrines of the Church of England.

† Dr. Edward Smith's weight was 196 pounds.

Performing this calculation we find—

	Carbonic Acid.	Body weight lifted through miles.
1	5.522 grains.	0.1400 mile.
2	7.440 grains.	0.1887 mile.
3	18.100 grains.	0.4591 mile.
4	25.830 grains.	0.6551 mile.
5	44.973 grains.	1.1406 mile.

It is easy to calculate that the external work done in the cases 3, 4, 5, was as follows:

	External work.
No. 3. Walking two miles per hour	0.1000 mile.
No. 4. Walking three miles per hour	0.1500 mile.
No. 5. Tread-mill	0.3256 mile.

Subtracting these amounts of work from the applied work, due to the production of carbonic acid, we find, as the quantities left for vital work, including circulation and respiration, and for the production of animal heat, per hour:

	Vital work and animal heat.
No. 3	0.3591 mile.
No. 4	0.5051 mile.
No. 5	0.8150 mile.

As I have already shown the work due to animal heat per day to be 6 miles, it follows that the work of animal heat per hour is 0.2500 mile.

Deducting this amount from the foregoing, we find for the vital work done, under the three different conditions—

	Vital work.
No. 3. Walking at two miles per hour	0.1091 mile.
No. 4. Walking at three miles per hour	0.2551 mile.
No. 5. Tread-mill work	0.5650 mile.

This result proves, in a striking manner, the great disadvantage under which an increased amount of muscular work is done in a given time; and it is quite in accordance with other results obtained by me from totally different experiments.

No two classes of animals can well differ more from each other than the cats and ruminants, one of which is intended by nature to eat the other. They differ in all respects as to food, the cats requiring a supply of fresh meat and blood for their health, and the ruminants being exclusively vegetable-feeders; yet in both classes we find a great development of muscular power, and of rapid action of muscles, qualities alike necessary to the pursuer and to the pursued. There can be no doubt that muscular work is developed in the cats from the combustion of flesh, and in the ruminants, mainly, if not exclusively, from farinaceous food. It is, however, worthy of remark, that the muscular qualities developed by the two kinds of food differ considerably from each other. The hunted deer

will outrun the leopard in a fair and open chase, because the work supplied to its muscles by the vegetable food is capable of being given out continuously for a long period of time; but in a sudden rush at a near distance, the leopard will infallibly overtake the deer, because its flesh-food stores up in the blood a reserve of force capable of being given out instantaneously in the form of exceedingly rapid muscular action.

In conformity with this principle, we find among ourselves an instinctive preference given to farinaceous and fatty foods, or to nitrogenous foods, according as our occupations require a steady, long-continued, slow labor, or the exercise of sudden bursts of muscular labor continued for short periods. Thus chamois-hunters setting out for several day's chase provide themselves with bacon fat and sugar; the Lancashire laborers use flour and fat, in the form of apple-dumplings; while the red Indian of North America almost transforms himself into a carnivore by the exclusive use of flesh-food; he sleeps as long and can fast as long as the puma and jaguar, and possesses stored up in his blood a reserve of force which enables him, like a cat, to hold his muscles for hours in a rigid posture, or to spring upon his prey, like a leopard leaping from a tree upon the back of an antelope.

If the preceding view of the muscular qualities developed by the two kinds of food be correct, important inferences suggest themselves as to the food that should be employed in relation to several kinds of work. Of these inferences I shall select two examples:

1. The nurses of one of our Dublin hospitals were formerly fed chiefly upon flesh-food and beer, a diet that seemed well suited to their work in ordinary times, which was occasionally severe, but relieved by frequent intervals of complete rest. Upon the occasion of an epidemic of cholera, when the hospital duties of the nurses became more constant, although on the whole not more laborious, they voluntarily asked for bacon fat and milk, as a change of diet from the flesh-meat and beer; this change was effected on two days in each week with the best results as to the health of the nurses, and as to their power of discharging the new kind of labor imposed upon them.

2. I have been informed, on competent authority, that the health of the Cornish miners break down ultimately from failure of the action of the heart and its consequences, and not from the affection of the lungs called "miners' phthisis." The labor of the miner is peculiar, and his food appears to me badly suited to meet its requirements. At the close of a hard day's toil, the weary miner has to climb by vertical ladders through a height of 100 to 200 fathoms before he can reach his cottage, where he naturally looks for his food and sleep. This climbing of the ladders is performed hastily, almost as a gymnastic feat, and throws a heavy strain (amounting from one-eighth to one-quarter of the whole day's work) upon the muscles of the tired miner, during the half hour or hour that concludes his daily toil. A flesh-fed man (as a Red Indian) would run up the ladders like a cat, using the stores of force already in reserve

in his blood; but the Cornish miner, who is fed chiefly upon dough and fat, finds himself greatly distressed by the climbing of the ladders—more so indeed than by the slower labor of quarrying in the mine. His heart, overstimulated by the rapid exertion of muscular work, beats more and more quickly in its efforts to oxidate the blood in the lungs, and so supply the force required. Local congestion of the lung itself frequently follows, and lays the foundation for the affection so graphically, though sadly, described by the miner at forty years of age, who tells you that "his other works are very good, but that he is beginning to leak in the valves."

Were I a Cornish miner, and able to afford the luxury, I should train myself for the "ladder feat" by dining on half a pound of rare beefsteak and a glass of ale from one to two hours before commencing the ascent.

The excretion of nitrogen by the cats and ruminants is very different, as might be expected from their food. I have ascertained that the urea discharged by a Bengal tiger and a sheep daily is as follows:

Bengal tiger	4,375 grains of urea.
Sheep	256 grains of urea.

It is worthy of remark, and serves to throw light on the meaning of the excretion of nitrogen from the body, that causes but slightly connected with muscular exertion in ruminants increase amazingly the excretion of urea. Thus I have found the following excretion of urea from a ram during the rutting season:

Ram, (rutting season)	1,493 grains of urea.

This amounts to a *sixfold* increase of urea, which cannot possibly be accounted for by the food consumed at the time, but requires us to assume a certain storing up of force, represented by nitrogenous compounds, which has been going on for a considerable period previous to the rutting season. A similar and equally remarkable storing-up of phosphates and carbonates takes place, previous to the rutting season, in the ruminants that shed their horns, which, in the *Cervus megaceros*, often weigh 90 pounds.

These remarkable phenomena remind us of the maxim of the wise Hippocrates, who recommends moderation in the use of the gifts of the Golden Venus as well as in those of Ceres and Bacchus: "Πόνοι, σιτία, ποτά, ὕπνος, ἀφροδίσια μετρια," with which may be compared its converse in the Latin proverb: "*Sine Cerere et Baccho, friget Venus;*" or, as the old proverb says, "When the wolf comes in at the door, love flies out at the window."

APPLICATION OF THEORY TO DISEASED CONDITIONS OF BODY.

The relation of food to work, complicated enough in health, becomes more so in disease, and the problem to be solved by rational theory becomes still more difficult. I cannot attempt even to sketch an outline of this part of my subject considered in general, but shall content myself with asking your attention to three remarkable examples of disease which

illustrate the principles I have attempted to lay down. These diseases are—

A. Typhus fever.

B. Cholera asiatica.

C. Diabetes mellitus.

A. *Typhus fever.*—In typhus fever a prominent symptom is the remarkable elevation of temperature, accompanied by an increased excretion of urea and carbonic acid by the kidneys and lungs, indicating (as no food is taken) an increased morbid metamorphosis of the blood and tissues. The temperature commonly rises to 104° F., representing an increase of upward of 5° F. above the normal temperature.

If we knew the cause of this increase of temperature, or, rather, of the increased metamorphosis of which it is the sign, we should know the cause of *typhus* fever, and learn to combat the disease on rational grounds. At present the cause is unknown, and, therefore, the physician is forced to treat the symptoms as they appear, instead of attacking the cause of the disease. Let us examine for a moment the terrible significance of the symptoms.

Your patient lies for nine or ten days supine, fasting, subdelirious, the picture of weakness and helplessness, and yet this unhappy sufferer actually performs, day by day, an amount of work that might well be envied by the strongest laborer in our land.

The natural temperature of the interior of the body is 100° F., while the temperature of the corresponding parts in typhus fever is at least 105° F. This seems at first sight a small increase—only 5 per cent. of the whole—but it is in reality $2\frac{1}{2}$ times as great as it appears, and actually amounts to $12\frac{1}{2}$ per cent., or one-eighth part of the total animal heat; for the total quantity of heat given out by the heated body is proportional (from Newton's law of cooling) to the elevation of its temperature above the temperature of equilibrium, toward which it tends. If we suppose this equilibrium temperature to be 60° F., then the quantities of animal heat given out in typhus fever and in health will be in proportion of 45 to 40, showing that the animal heat of typhus exceeds that of health by one-eighth of its amount.

We have already seen that the work due to animal heat would lift the body through a vertical height of six miles per day; and it thus appears that an additional amount of work, equivalent to the body lifted through nearly one mile per day, is spent in maintaining its temperature at fever heat.

If you could place your fever patient at the bottom of a mine twice the depth of the deepest mine in the duchy of Cornwall, and compel the wretched sufferer to climb its ladders into open air, you would subject him to less torture, from muscular exertion, than that which he undergoes at the hand of nature, as he lies before you, helpless, tossing, and delirious, on his fever couch.

The treatment of this formidable disease in former times consisted of

purging, vomiting, and bleeding the patient, with the view of eliminating an imaginary poison, and so helping nature to terminate the disease.[*]

In modern times, thank God, the physician either does not interfere at all, or adopts the rational process of retarding the disintegration of the tissues consumed to supply the fever heat, by furnishing in their stead fuel, in the form of wine and beef-tea, sufficient to maintain the increase of temperature imperiously required.[†] This practice may be justly considered rational, because the condition of the circulation admits of its application; and it is considered good, because it has been rewarded with success in the hands of the skillful clinical physician. In concluding this sketch of the prominent symptom of typhus fever, and as an illustration of the eagerness with which every possible combustible in the body is made use of, I may mention, on the high authority of Dr. Stokes, of Dublin, that the very urea excreted by the kidneys is not permitted to leave the body without first paying its tax to fever, by being burned into carbonate of ammonia, thus rendering the urine of an advanced case of bad typhus fever eminently alkaline.

B. *Asiatic cholera.*—This remarkable disease presents, as every one knows, three distinct stages, viz:

1. The premonitory stage of diarrhœa.
2. The stage of collapse.
3. The stage of consecutive fever.

The stage of collapse exhibits the following symptoms: Vomiting or purging; muscular cramps; suppression of bile and urine; lowering of

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[*] *Νούσων φύσιες ἰητροί.*—Epid. vi, Sect. v, 1.

[†] It is not intended by this to assert that a high temperature, 104° to 108° F., must be maintained in order that the disease may terminate favorably, for the very contrary is the fact. The blood, in typhus, as in other pyrexies, is a fluid possessed of greater oxidizing power than it has in health; in consequence of this, an increased metamorphosis of tissues takes place, accompanied, of course, by an elevation of temperature, which measures precisely the oxidizing power of the blood, and the risk to life in typhus is directly proportional to the rise in temperature. The indications of the sphygmograph are similar to those of the thermometer, a "*full dicrotic*" pulse corresponding to a temperature of 103° F., and the pulse of "*death agony*," with the heart's first sound gone, corresponding to a temperature of 109° F. There is no case on record of recovery from a condition marked by such a pulse and temperature.

The effects of alcohol, administered in fever, when the temperature does not exceed 105° F., are twofold—immediate and secondary. The immediate effect is to supply a hydrocarbon to the blood, which is decomposed by it in preference to the body tissues. The secondary effect of alcohol is to change the blood itself, which thus loses its oxidizing qualities; in consequence of which the temperature falls, the hyperdicrotic character of the pulse disappears, and the destructive metamorphosis of the tissues becomes lessened. The statement here given of the effects of alcohol given in typhus, to the exact amount required by the condition of the blood, in narcotic doses, is borne out by clinical observation, and is independent of any theory as to the cause of typhus.

It is not at all improbable that the theory of contagious disease, that each such disease owes its existence to a special living organism and not to an organic poison, may ultimately prove to be correct.

body temperature to 95° F.; extreme prostration of strength; extremities pulseless; and face hippocratic.

When death occurs during collapse, the following symptoms are usually found on careful examination of the corpse: The temperature rises to 103° F.; the muscles give out their characteristic susurrus CCC, and exhibit spontaneous movements; the whole train of symptoms producing the effect of a ghastly attempt at resurrection.*

In this disease we have phenomena respecting animal heat the very reverse of those found in typhus fever; the body performing one vertical mile short of its daily work, instead of one mile in excess. The prostration of strength resulting from this deficient combustion is so great that death is often caused by bringing the patient to hospital in a cab instead of upon a stretcher, by his walking up a dozen steps into his ward, and sometimes even fatal results have followed a sudden effort to sit up in bed to vomit.

The rise of temperature after death, and the continuance of muscular susurrus and motion, tend to prove that the impeded circulation, which is the prominent symptom in cholera collapse, is due to constriction (probably vasomotor-nervous) of the capillaries, in consequence of which the muscles are deprived of their supply of freshly oxidized blood, the result of which is necessarily contraction and cramp, which produces the excessive agony that characterizes this disease.

All authorities on cholera, whether their object be to "impede" or to "assist" nature, are agreed that medicines, whether astringent or purgative, are not only useless, but dangerous, in the stage of collapse.

It is useless to give alcoholic fuel to restore the loss of animal heat, for there is no circulation to cause the oxidation of the hydrocarbons.

It is equally useless and more dangerous to give opium, to check the remaining purging that exists; for if vomiting have ceased, your acetate of lead and opium pills lie as if in the stomach of a corpse, and at the termination of collapse, your patient enters upon the consecutive fever, with perhaps a dozen grains of opium in his stomach, placed there like an explosive shell by your ill-timed zeal, and rapidly passes into a comatose condition, from which he never for a moment rallies. His death is always accredited by the registrar to cholera morbus and not to opium.

Purgatives and emetics† in cholera collapse effect the same object as opium, but with greater rapidity. In the stage of blue collapse, the chances of life and death are almost exactly equal, and the slightest additional loss of force turns the wavering beam on the side of death. The effects of a brisk purgative or emetic (if they act) upon a patient, unable to climb a dozen steps, or sit up for a quarter of an hour, without

* It is startling, on making a post-mortem examination of a cholera patient alone and by candle-light, to witness, on the first free incision of the scalpel, the hand of the corpse rise slowly from its side and placed quietly across its breast.

† When mustard is used, its conservative effects as a stimulant sometimes counteract its destructive effects as an emetic.

fatal syncope, may be easily imagined; and the use of them cannot be justified by any arguments borrowed from right reason.

A remarkable though transient improvement takes place in cholera collapse by the injection of warm water (brought to the specific gravity of serum by the addition of mineral salts) into the veins or bowels; the patient loses the cramps, feels that he is about to recover, speaks to his friends, and often transacts whatever business is necessary; but speedily falls back into collapse. The improvement in his condition is altogether due to the temperature of the fluid injected, which supplies for a brief period the deficient animal heat, permits a partial oxidation of the blood, restores the capillary circulation in the muscles and so destroys their cramp, and, by supplying the deficient work required, removes for the moment the fatal prostration of strength. Any one who has witnessed the remarkable effects of warm liquids thus injected in cholera collapse must feel that recovery would be certain if the improvement could by any possibility be made permanent.

Our hopes for the future, as to the treatment of cholera, lie, as I believe, in the direction of supplying to the body directly its lost animal heat. I have witnessed the happiest results from an injection of warm salt water into the bowels, assisted by hand friction of the surface with turpentine and chloroform, and the application of bags of hot salt along the spine; in cases treated in this manner, we may expect to witness cessation of muscular cramp, restoration of perspiration to the skin, with increase of capillary circulation, and finally, to reward our efforts, a return of the excretions of urine and bile; when these reappear, all vomiting and purging cease, and our patient is almost cured.

After recovery, the contrast between the cholera and fever patient is as great as it was during sickness. The fever patient has been overworked for nine or fifteen days without a suitable supply of food, and when convalescent experiences a complete exhaustion of strength that lasts for many weeks. The cholera patient, on the other hand, has been prevented from working by constriction of the capillary vessels, caused by the absorption of the cholera poison,* and feels, on recovery, much like a man that has been half drowned, while the fever patient resembles a man that has been half starved; the one is able to return to his work in the course of a few days, the other only after the lapse of as many weeks.

There are two popular superstitions prevalent among medical men respecting nature, which yearly slaughter hecatombs of victims, viz, that nature is simple in her operations, and beneficent in her intentions; she is often both simple and beneficent, but at other times she is unquestionably both complex and malevolent.

An Egyptian fable informs us that the votaries of goddess Nature were divided in opinion as to whether she was transcendently beautiful

* Whatever this may be, its period of incubation is 49 hours; that of strychnine is 22 minutes.

or hideously ugly; and that, in order to keep up this difference of opinion which suits her purpose, she always wears a thick veil over her face.

> "For, with a veil that wimpled everywhere,
> Her head and face were hid, that mote to none appear;
> That some do say was so by skill devised,
> To hide the terror of her uncouth hue
> From mortal eyes that should be sore agrised;
> For that her face did like a lion show,
> That eye of wight could not endure to view;
> But others tell that it so beauteous was,
> And round about such beams of splendor threw,
> That it the sun a thousand times did pass,
> Nor could be seen but like an image in a glass."

Before trusting nature in the matter of cholera, and proceeding to help her, it would be well to inquire whether she intends to cure the patient by her evacuations or to put him into his coffin. For myself, I greatly mistrust her, and would wish to ask, previous to assisting her, whether she is really my mother or only my stepmother. Our experience in Dublin has shown that no more effectual mode of shortening life could be devised in cholera than the "eliminant" treatment; and it was accordingly abandoned as soon as tried in that city.

It is much to be regretted that an authority so deservedly held in high repute as that of Sir Thomas Watson can be now quoted in favor of the treatment of cholera, by the maxim, *similia similibus curantur.* So far as Dr. Watson has informed us, his change of opinion rests upon the statements of others, and not upon his own experience. He has suddenly become an advocate of the castor oil, rhubarb, calomel, and eliminant treatment of cholera, and writes as follows:

"When I last spoke on this subject in these lectures, I stated that the few recoveries which I had witnessed had all taken place under large and repeated doses of calomel, but I could not venture to affirm that the calomel cured them. At present I am much disposed to believe that by its cleansing action the calomel may have helped the recovery; and after all that I have since seen, heard, read, and thought upon the matter, I must confess that in the event of my having again to deal with the disorder, I should feel bound to adopt, in its generality, the evacuant theory and practice."

Sir Thomas Watson omits to add that the cases here referred to were only six in number, of whom three died and three recovered, which is exactly what might have been expected if he had not interfered at all.

Cholera from Bengal visits these islands at intervals of about seventeen years, and it is much to be feared that on its next outbreak hundreds of patients will be sacrificed, in obedience to the dogma that asserts it to be our duty to assist nature.

C. *Diabetes mellitus.*—This disease furnishes us with one of our best proofs that all the chemical changes, by means of which work is produced, take place in the blood and not in the tissues of the body: and,

at the same time, an examination of its phenomena explains satisfactorily the regimen and diet which has been found, by experience, most suitable to the diabetic patient. I shall illustrate the disease by a case which was placed under my control by Dr. Stokes some years ago.

A young man (æt. 20) named Murphy suffered from fever (enteric?) in November, 1859, and on recovering became diabetic; he was admitted into the Meath Hospital in October, 1860, where he remained under my observation until his death, on the 12th January, 1861.

He was allowed, for nine weeks, to eat as much as he liked of certain kinds of food, which were varied, week by week, to suit his wants, my object being to obtain, if possible, the natural constants of the disease, undisturbed by external interference; the only medicine used by Dr. Stokes's order being opium, to produce sleep, and a little creosote occasionally, to promote digestion. As the details of this experiment have been fully published, I shall confine myself to the final results. His food and excretions were analyzed from week to week, so as to determine the total quantities of sugar-forming and urea-producing food, as well as the sugar and urea actually excreted.

During six of the nine weeks, the sugar excreted was in excess of the sugar ingested; and the means of the whole nine weeks' daily excretion and ingestion of sugar were—

	Grains.
Sugar excreted	9,773
Sugar ingested	9,321
Difference	452

During two of the nine weeks of observation, the urea excreted was in excess of the urea ingested; and the means of the whole nine weeks' daily excretion and ingestion of urea were—

	Grains.
Urea excreted	1,182
Urea ingested	1,349

The foregoing facts illustrate strikingly one of the prominent symptoms of diabetes, viz, the canine appetite; the quantity both of sugar-producing and urea-forming food consumed is more than double what is necessary to maintain a vigorous laborer in perfect health. An examination of the excretions explains the other prominent symptom of diabetes, viz, the complete prostration of strength in the patient, notwithstanding the great amount of food consumed.

In a state of health, food produces three excretions only, viz, urea, carbonic acid, and water; in diabetes, the farinaceous foods appear in the excretions as sugar, and not as carbonic acid and water; and the work necessary to maintain animal heat must be provided altogether at the expense of flesh food, which is the very form of food least fitted to maintain it.

The diabetic patient resembles a racing steamboat on the Mississippi whose supply of coals is exhausted, and whose cargo furnishes nothing better than lean pork hams to throw into the furnace to maintain the race. It cannot be wondered at that our poor patient, under such disadvantageous conditions, fails to keep in the front.

Let us compare together the minimum of work necessary to keep Owen Murphy alive, with the work actually supplied to him by the food digested.

1. I have already stated that Dr. Ranke found 660 grams of carbonic acid excreted daily, in the extreme fasting condition, when he weighed 67 kilograms. Now, since—

$$\begin{aligned} 660 \text{ grams} &= 10185.35 \text{ grains}, \\ 67 \text{ kilograms} &= 147.71 \text{ pounds}, \end{aligned}$$

we find 69 grains per pound of body weight as the minimum excretion of carbonic acid consistent with continued life.

This quantity of carbonic acid represents a work generated by its production that would lift its corresponding pound of body weight through a height of—

$$69 \times \frac{6}{22} \times 8080 \times \frac{9}{5} \times \frac{772}{7000 \times 5280} = 5.716 \text{ miles.}$$

Under ordinary conditions, the greater part of this carbonic acid and work is produced by the digestion of farinaceous food; but since, as we have seen, the farinaceous food is excreted as sugar in the diabetic patient, and, therefore, does no work at all, the whole of the foregoing work must be done by the digestion of other kinds of food.

I have already shown that it follows, from Lavoisier's experiments, (confirmed in a remarkable manner by those of Regnault,) that the work done by the combustion of carbon in the body is to the work done by the combustion of hydrogen in the proportion of 9068 to 3024, almost exactly 3 to 1; hence we have the work done by Owen Murphy, as a minimum in health—

	Miles.
Due to carbon	5.716
Due to hydrogen	1.905
	7.621

This result is somewhat in excess of the truth, for the same reason that the calculated *digestion coefficient* of proteine is in excess of that found by Frankland from experiment; for the combustion coefficients of carbon and hydrogen in organic compounds are slightly less than when free. If we are permitted to reduce 7.621 miles in the same proportion as in the digestion of proteine, viz, 48 to 43, we shall find—

Owen Murphy minimum of work consists of body weight lifted through 6.83 miles.

Let us now compare this minimum with the work actually performed

by him when suffering from diabetes, by the digestion of flesh food and production of urea.

2. I have already shown that the work produced by the formation of 501.28 grains of urea is 704 foot-tons by calculation from the composition of proteine and urea. This result should be reduced in the proportion of 48375 to 43155, in order to obtain the work given by Professor Frankland's experiments. Making this reduction, we find that 500 grains of urea correspond to 626.3 foot-tons of work, or 100 grains urea to 125.26 foot-tons; or, in other words, *every four grains of urea excreted correspond to five tons lifted through one foot.*

Owen Murphy excreted, on an average, 1,182 grains of urea daily during nine weeks, which, by the foregoing rule, are equal to—

$$1475 \text{ foot-tons} = \text{Murphy} \times x$$

where x represents in miles the height through which the patient could be lifted by the work done per day, and is equal to—

$$x = \frac{1475 \times 2240}{93.56 \times 5280} = 6.69 \text{ miles.}$$

This result is almost exactly equal to that already found as the minimum consistent with continued life, and explains in the most satisfactory manner the complete prostration of the patient, notwithstanding the consumption and digestion of more than double the usual quantity of flesh food.

In corroboration of the foregoing conclusion, I may mention that Murphy's temperature was found to be constantly 2° F. below that of other patients (chronic) placed in the same ward, and, in other respects, under similar conditions.

His unfavorable symptoms (so long as his powers of digestion were not impaired) were invariably alleviated by the free use of flesh food and fat, the latter being instinctively preferred by him; so much so, that during the delirium that preceded his death for twenty-four hours, he raved incessantly about "fat, roasted fat, which the angels of heaven were preparing for him."

I have studied many other cases of *diabetes mellitus*, and found similar results in all; but I feel it to be unnecessary to describe them, as one well-ascertained train of phenomena, carefully observed and recorded, is quite sufficient to establish the order of nature.

CONCLUSION.

I have, now, Mr. President and gentlemen, to apologize for the length of time during which I have spoken, and to thank you for the patience with which you have listened to me. I am well aware how much I am indebted to your kindness, for I labored under two serious disadvantages in addressing you—in the first place, I had undertaken a task beyond my strength; and again, my address is made shortly after you had, like myself, been charmed and instructed by the luminous, learned, and

eloquent oration of Professor Rolleston. I felt confident, however, that I possessed one advantage that he did not; I was a stranger in Oxford, and believed that my faults in matter and style would be leniently criticised; in this expectation, I am happy to say I am not disappointed; and again I thank you for your kindness. Two other advantages I share with him, which have contributed to his address as much as to my own—a profound respect and reverence for all honest laborers in search of truth, whether they have preceded us by twenty years or by two thousand years; and an unwavering confidence and faith in the future that lies before the science of medicine. We traverse a sea mapped with imperfect charts, but assured of a safe guide in our compass and stars; but we cannot afford to neglect a single rock or shoal, buoyed for us by the skill and care of those that have preceded us. Let us follow their example, and mark with conscientious care, for our successors, the dangers we ourselves discover and escape.

Assembled, as we are, within the halls of the University of Oxford, the center and heart of all that is intellectual and religious in the life of England—a university that borrows its accurate logic, as well as its refined ethics, from the lips of Aristotle; that reverences Euclid as the fountain and source of its elegant geometry; and sits at the feet of Homer, Pindar, and Eschylus, to learn its poetry—we need not fear that Hippocrates and Galen will ever want admirers and students; but the Oxford of to-day has taught us, what many did not anticipate, that she is equally ready and skillful, as she has proved herself to be in cultivating literature, to devote her vast intellectual energies to the encouragement and development of the natural sciences, based upon the solid and only permanent foundation of mathematical research. The efforts made within the last few years by Oxford to encourage within her walls the mathematical and natural sciences, have won for her the respect, and warmed toward her the hearts, of all that search for truth in the study of nature. Our brothers in Oxford, like the Athenians at Syracuse, have gone on board the fleet, while we watch them from the shore, sympathizing in the sea-fight; as they win, we shout; when they fail, we weep.

Long may the union of the far distant, but never to be forgotten, past, with the living present, that now exists in Oxford, continue. No science, no profession, can benefit so much by it as that of medicine.

HYDROGEN AS A GAS AND AS A METAL.

By Dr. J. Emerson Reynolds.

Notes of a lecture delivered in the theater of the Royal Dublin Society.

When the programme of this course of lectures was published, it became evident that the subject of the present one was, by a singular coincidence, closely connected with that of two of the earlier lectures of the series. I refer to the discourse of Mr. Stoney on "Meteoric Showers," and of Professor Ball on "Nebulæ." In the latter lecture, we learned that many of the thin mists observable in the heavens are not star clusters, as they were long supposed to be, but are enormous masses of gaseous matter in a state of intense ignition. The examination of the light emitted by these nebulæ enables us to state with certainty that at least one elementary body well known upon this earth is present in all of them as a principal constituent, and that element is one which chemists call hydrogen. In Mr. Stoney's lecture on "Meteoric Showers," he pointed out that some of these strange visitors to our globe, the meteoric stones, are found to contain pent up within them a certain gas, which gas has been shown by analysis to be hydrogen. We find, then, this hydrogen in enormous quantities throughout space, and at so great a distance from our planet that the human mind is unable to appreciate the interval which separates us from even the nearest of those mighty gaseous oceans. Again, we find this hydrogen carried to our planet by those strange wanderers of interstellar space, the meteors. And, finally, we have it on this earth, not in the free state, it is true, but as an essential constituent of one of the most important components of this globe, viz, water.

Our object in this lecture, then, is to study this remarkable element, hydrogen, as we meet with it here, to determine some of its chief properties, and to ascertain its nature.

It has been already said that our chief storehouse of hydrogen on this earth is water, but we find it in many other well-known bodies; for instance, in the dreaded "fire-damp" of our coal mines we have the hydrogen combined with another element, carbon. Again, common coal-gas contains a large proportion of hydrogen; and I have only to mention that this same body is an essential constituent of the bread we eat, the sugar we mix with our tea, the clothes we wear, of our flesh and blood too, in order to show that this is one of the most widely diffused of that class of bodies known to chemists as elementary forms of matter. But though we find hydrogen in all the substances mentioned just

now, and in many more besides, for the purpose of the present lecture we shall confine our attention to one of its most remarkable and widely diffused compounds, viz, water.

Water, in whatever condition we find it in nature, whether solid, liquid, or gaseous, (as steam,) is a compound body, being made up of two simple forms of matter—the one called oxygen, the principal constituent of the air we breathe, and the other hydrogen. Chemists are acquainted with several modes of breaking up the compound water into its two elementary components; but one of the most convenient methods we can employ for effecting this analysis of water is to make electricity tear asunder its two constituents. When water is made part of a galvanic circuit, by plunging the two poles of a galvanic battery into a vessel of the liquid, we find that bubbles of gas are evolved at each pole. By a very simple arrangement, we can collect the gases given off at each terminal of the battery, and we then find, on testing the products, that two colorless gases are obtained, possessing widely different properties. We observe that the gas liberated at the end of the wire connected with the platinum plate of the galvanic battery (the positive pole) is colorless, heavier than atmospheric air; and that when a glowing wooden match is dipped into a vessel filled with the gás, the wood burns with great brilliance, though the gas does not itself take fire. This peculiar gas is therefore a powerful supporter of combustion, though incombustible itself, and is called oxygen. We now turn our attention to the gas given off at the negative pole of the battery, *i. e.*, at that connected with the zinc plate. This is also found to be a colorless gas, but very much lighter than air, and incapable of supporting the combustion of a burning taper plunged into it; but though not a supporter of combustion in the ordinary sense of the term, it possesses the remarkable property of burning itself with a pale lambent blue flame. This is the gas hydrogen—the remarkable body whose chief properties we have now more especially to study.

[Other modes of liberating hydrogen from water were shown, and the leading properties of the gas demonstrated.]

When hydrogen burns in air, its sole product of combustion is water; hence the name of this remarkable substance, signifying "water-producer." But oxygen and hydrogen can also be made to combine and produce water when presented to each other *in conditione nascenti*, or at the moment of liberation from other forms of combination. The importance of knowing this fact will be apparent further on.

The beautiful researches of the late Professor Faraday have made us familiar with the fact that many of the gases known to chemists are merely the vapors of extremely volatile liquids; for, on subjecting these gases to very great pressure and to intense cold, in many cases liquids are obtained and even solids, which, on removal of the pressure under which they were produced, resume the gaseous condition at ordinary temperature. Hydrogen has been likewise subjected by the learned

Dr. Andrews, of Belfast, to enormous pressures, and to extremely low temperatures, but without exhibiting the slightest tendency to condensation. Hence it has generally been considered a permanent gas; but recent investigations, conducted by the master of the British Mint, the learned and distinguished Professor Graham, tend strongly to show that hydrogen gas, as we meet with it under ordinary circumstances, is really *the vapor of a highly volatile metal.*

It may be now generally stated that when a solution containing a metal and a non-metallic body is decomposed by a galvanic current, the metal is usually deposited on the negative pole, and the non-metallic body on the positive electrode. If, for instance, we take a solution of common blue vitriol, or sulphate of copper, and plunge the poles of a battery into the liquid, we find that immediately metallic *copper* is deposited on the wire forming the *negative* pole, while the sulphuric acid (a non-metallic body) appears at the positive end. If now we plunge the two poles into plain water, which, as we have already seen, is a compound of hydrogen and oxygen only, the hydrogen appears at the *negative* pole and the oxygen at the opposite one. We learn, then, in applying the galvanic test, that hydrogen arrays itself on the side of *metals*, and this fact is completely in accord with the view of its nature referred to above.

Again, it is a well-known fact that metals are capable of uniting with each other so as to form compounds called *alloys;* thus, brass is an alloy resulting from the fusion of the two metals copper and zinc in suitable proportions. But it is not always necessary that the two metals should be heated together in order to make them combine; for, if we take a slip of gold and plunge it into some of the liquid metal, mercury, or quicksilver, as it is called, the gold and mercury combine with each other to form an alloy or "amalgam," possessing a strong metallic luster. To go just one step further: if we convert this metal, mercury, into a colorless, invisible gas, which we can do by applying sufficient heat, and if into a vessel filled with this mercury gas we plunge a slip of gold, we find that the two metals combine or amalgamate nearly as easily as under ordinary circumstances. If, then, we can accomplish so much with the mercury gas, whose metallic nature is certain, why may we not make hydrogen gas alloy with some metal also?

By the very beautiful and interesting discovery that certain metals possess the power of absorbing enormous quantities of hydrogen without loss of metallic appearance, Professor Graham has greatly strengthened the evidence in favor of the metallic nature of hydrogen, and has even gone so far as to calculate the density of the metal, which he calls "hydrogenium."

Professor Graham found that certain metals—palladium and platinum more particularly—possess the extraordinary power of absorbing large volumes of hydrogen gas, and retaining it in some kind of combination. In order to demonstrate this, it is only necessary to take a plate of pal-

ladium foil, and, having connected it by a wire with the zinc end of a galvanic cell, to immerse the plate in acidulated water, the positive pole being connected with a plate of platinum likewise immersed in the liquid, hydrogen is immediately set free at the palladium surface, and oxygen at the platinum end. The latter gas is given off in bubbles from the platinum, whereas the hydrogen is absorbed by the palladium.

The palladium is capable of thus absorbing about *nine hundred times* its volume of hydrogen, and this enormous absorption or condensation of hydrogen within the pores of the metal takes place without any material alteration in the color of the palladium, *the latter retaining its metallic appearance.* This, among other circumstances, induced Professor Graham to regard the charged palladium as being a true *alloy* of palladium with the metal *hydrogenium;* for it has been found that when two metals unite, the compound resulting retains the characters of a metal, whereas this is not the case when a metal and a non-metallic body combine. In order to exhibit this absorption on a large scale, I have arranged the following experiments:

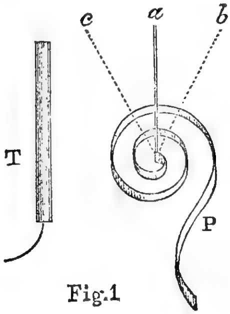


Fig.1

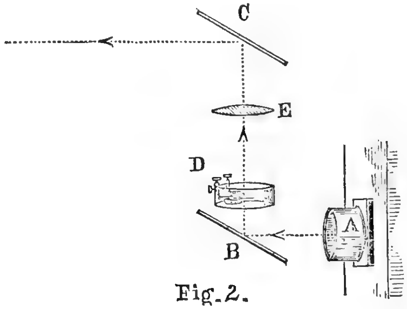


Fig. 2.

A small glass cell is partially filled with water, slightly acidulated with sulphuric acid. Into this water a bar of metallic tin is dipped; this bar is of the size shown at T, Fig. 1, and is supported in a horizontal position by means of a varnished wire clamped to the side of the glass cell with the aid of a binding-screw. Having secured T in its position, we now take a slip of rather stout palladium foil, about four inches long, and a quarter of an inch wide, and coil it as shown at P; to the end within the spiral is now attached a fine fiber of glass by means of a minute quantity of cement, and this is so adjusted that the glass shall act as a needle-indicator, as shown in the diagram. The palladium is then attached to the edge of the glass cell by means of a binding-screw and varnished wire. When the cell, so arranged, is placed at D, Fig. 2,* the image is projected on the screen, as in Fig. 1.

* This projection may be most conveniently effected by means of the apparatus shown in section at Fig. 2, and which was arranged for me by Mr. Yeates, of Dublin. At A we have the front of a lantern with the object-glasses removed, the light oxyhydrogen, oxycalcium, or any other, having to pass only through the condensers. After passing the condensers, the rays fall on an ordinary mirror, B, suitably inclined to the beam of

Without disturbing the apparatus, we now connect, by means of the binding-screw and a copper wire, the palladium spiral with the zinc plate of a galvanic battery—one or two cells are sufficient—and the tin rod is connected with the opposite plate of the battery. Immediately on making contact, the water is decomposed by the electric current, hydrogen being liberated at the surface of the palladium, and oxygen on the tin. The latter gas is set free in bubbles, but the hydrogen, instead of being liberated in the gaseous form, is absorbed by the palladium; the volume of the metal is thereby increased, and the coil opens out as if endued with vitality. In doing this the glass needle is made to travel over several feet on the screen, and assumes the position represented by the dotted line *b*.

In this way we are able easily to show the expansion of the palladium then charged with hydrogen; but it is obvious that, on the removal of the hydrogen, the needle should return to its original position. In order to take away the hydrogen from the palladium, we have simply to reverse the poles of the battery; that is to say, we now connect the tin bar with the negative wire, and the palladium with the other pole. Now, on passing the current, oxygen is set free at the surface of the palladium spiral, and hydrogen on the tin. The oxygen, liberated in juxtaposition with the hydrogenized palladium, unites with the hydrogen, and forms water, no material amount of oxygen appearing at the surface of the palladium until all the hydrogen has been removed from the latter.

If we watch the effect of the change produced in this way on the screen, we find that, according as the hydrogen is removed from the palladium, the needle begins to move from the position it assumed at *b*, when the spiral was charged with hydrogen, or alloyed with hydrogenium, if we prefer the term, until it returns to the starting-point *a*. Instead of resting there, as it ought to do, however, it travels on steadily until it reaches the position *c*; thus demonstrating the singular fact that the contraction of the palladium on losing its charge of hydrogen is *double* the amount of its previous expansion. Professor Graham accounts for this singular phenomenon by supposing that the particles of the metal slide over each other in a lateral direction, so that the band of the palladium is unusually shortened, though its density is not in-

light, so that the latter may be reflected in a vertical direction, as indicated by the dotted line. Immediately above this mirror is placed on a wooden support the flat glass cell D, about an inch in depth, and of any required size. Above this vessel is placed a double convex lens, E; the height at which this must be placed above D will depend on the focus of the lens, and is readily found by ascertaining the point at which the image of the object placed in D is most clearly defined on the screen. The rays reflected from the first mirror, B, and having passed through D and E, now fall on a second mirror, C, by which means they are projected on to the screen, and, when the focus is properly adjusted by shifting E, a well-defined image of any object placed at D is shown erect on the sheet.

creased, since reduction in length is accompanied by a proportional increase in other dimensions.

It is found that this palladium foil charged with hydrogen possesses most powerful reducing properties; that the hydrogen within it is just as capable of reducing silver salts as a metallic layer of zinc would be. As illustrating this point, we may cite an experiment: A plate of palladium foil was charged with hydrogen, as above described, and then immersed in a solution of corrosive sublimate; almost immediately a white precipitate of calomel made its appearance, and, when the action proceeded a little further, mercury was reduced. On repeating this experiment with a slightly alkaline solution of nitrate of silver, the metal was quickly thrown down on the palladium plate, and, when an alkaline solution of gold was used, the metal was likewise precipitated. These precipitates were obtained under circumstances in which the ordinary hydrogen gas or palladium foil alone would have been quite incapable of effecting reduction.

We have already seen that hydrogen can be liberated from the charged palladium by presenting to it oxygen *in conditione nascenti*, but it can also be set free by heat, or by reduction of the pressure of the atmosphere surrounding the charged plate. If a palladium wire be made to absorb as much hydrogen as it can take up, and if the tip of the wire be heated in the flame of a spirit-lamp, hydrogen gas is liberated, and burns on the surface of the palladium, the flame continuing until all the gas has been set free. Again, if a similarly charged wire be placed under the receiver of an air-pump and the air exhausted, the hydrogen is completely liberated in its ordinary gaseous condition.

In order to complete this account of hydrogenium, it is only necessary to mention that its density is stated to be nearly 2, or about equal to the specific gravity of the metal magnesium; but the means by which Professor Graham has arrived at this result, though very ingenious, are so unsatisfactory that we must take this estimate as being a mere approximation to the truth. In all probability we must wait for the accurate determination of the specific gravity of hydrogenium until the metal itself will have been isolated in a pure condition.

Thus, in the course of this lecture, we have liberated hydrogen, "*as a gas*," from water, and in this condition have studied some of its properties. Again, we have made this remarkable element alloy itself with palladium; and when thus appearing in the guise of "*a metal*," we have noted the chief phenomena it gives rise to. And now, like the bird from its cage, we will set free this hydrogen from its prison-house of palladium, and let it mingle with the mighty aerial ocean in which we live and move.

A LECTURE ON THE IDENTIFICATION OF THE ARTISAN AND ARTIST.

By Cardinal Wiseman.

[In the spring of 1852 an association was formed by the Catholics of Manchester and Salford, in England, to raise funds for the education of the poor. The committee, in aid of this purpose, invited Cardinal Wiseman to deliver an address upon some literary subject of general popular interest. The invitation was accepted, and the following admirable address, for a copy of which we are indebted to a friend, was delivered in the Corn Exchange, Manchester. We have thought that a more general diffusion of it would be acceptable to those who are interested in the establishment of schools of art in this country, and accordingly have given it a place in this report.—J. H.]

Ladies and Gentlemen: I ought certainly to commence my address to you by thanking you for the extremely kind manner in which you have been pleased to receive me; but I feel that I must not waste your time in mere expressions of a personal character, feeling rather that I shall have to tax your time and your attention to a considerable extent. I will, therefore, enter at once upon the proposed subject of my address, which has already been communicated to you by my old and excellent friend, the Bishop of Salford. And I am sure I need not say, for he already has well expressed it to you, that it is a topic which at the moment has engaged its full share of public attention, as drawing to itself the interest of all the educated classes, and it is in fact a topic connected with important questions, the solution of which may have to exert an important influence not only on our social but likewise on our moral progress.

The topic on which I have to address you, then, is the CONNECTION OR RELATION BETWEEN THE ARTS OF PRODUCTION AND THE ARTS OF DESIGN.

By the arts of production, I mean naturally those arts by which what is a raw material assumes a form, a shape, a new existence, adapted for some necessity or some use in the many wants of life. Such is pottery; such is carving in its various branches, whether applied to wood or to stone; such is the working of metals, whether of gold or silver or brass or iron; such is the production of textile matters, of objects of whatever sort and for whatever purpose; such is construction in its different branches, commencing with the smallest piece of furniture, and ascending to a great and majestic edifice. By the arts of design, I understand those which represent nature to us in any form, or which bring before us beauty, whether in form or in color.

Now, these arts ought, as every one agrees, to be in close harmony one with the other; but that harmony which I wish to establish between them must be an honorable union, an equal compact, a noble league.

There is not to be one the servant, and the other the master; each must be aware of the advantages which it can receive as well as those which it can confer. Thus the arts, for instance, of design, will have to give elegance of form, grace of outline, beauty of ornament, to that which is produced by the other class of arts; and they in their turn have to transmit and multiply and perpetuate the creations of the arts of design. Now, it is agreed on all hands that as yet this complete harmony does not exist; that we have far from arrived at that mutual application of the one class to the other which gives us a satisfactory result. It is unnecessary, I believe, to bring evidence of this. As we proceed, I trust that opportunities will present themselves of bringing before you authorities for that assertion. But I may say, at the very outset, that the report which is published by the department of practical art is almost based upon the acknowledgment that as yet we have not attained that application of the arts of design to the arts of production which we desire, and which is most desirable to the arts of production to obtain. It acknowledges the existence of a necessity for much more instruction than has yet been given. It allows that for several years—thirteen years, at least—of the existence of schools of design they have not been found fully to attain their purpose, and a new organization and a new system has now begun to be adopted. No one can appreciate, I trust, more than I am inclined to do myself, the advantages which must result from the multiplication of these schools of design as applied to manufactures, and other great improvements which they have already begun to confer, and will continue, no doubt, still more to bestow upon the industrial classes. I believe it most important to propagate to the utmost the love of science, the love of art. *I believe it most useful to accustom every child to its first rudiments, its elementary states.* I think, if we can make drawing a part of universal education, a great deal will be gained. But this, certainly, cannot be enough. I am willing to grant that we shall have a great improvement upon what we have produced in the form of art. I believe that we shall see better designers; men with better imaginations; men who understand the harmony and combination of colors better, and who can give to the artisans patterns which will greatly improve every department of our industry. But, I ask, is that sufficient? Will this bring art up to what we desire? This is the great question. This is the subject of which I am going to treat. It appears to me that there is a very simple mode of looking at it; and it is the one, consequently, which I shall adopt. It is a question partly of experience. It is a lesson much of which history can teach us; and I desire to bring before you such facts as seem to me to bear upon the question, and to enable us to come to a practical and satisfactory conclusion. I will endeavor to state the question under a very simple, but, perhaps it may appear, not a very practical form.

There is now a great desire to form, not only in the capital, but also in all great cities where industry prevails, museums, which should

contain all the most perfect specimens of art antiquity in every age has left us of beauty in design and elegance in form. We wish that our artisans should have frequently before them what may be considered not merely actual models to copy, but likewise such objects as may gradually impress their minds with feelings of taste. Now, I should like to have the construction, the forming, of such a museum. And, in describing it, I will confine myself entirely to one small department—that of classical art, classical antiquity—because I know, that, for a museum intended to be practical to the eyes of artisans, there is a far wider range of collection to be taken than that to which I will confine myself. Well, now I imagine to myself a hall at least as large as this, and of a more elegant and perfect architecture. I will suppose it to be formed itself upon classical models; and around it shall be ranged, not merely plaster casts, but real marble statues and busts collected from antiquity. I would range them round the throne so that each could be enjoyed at leisure by the student. There should be room for the draughtsman to take a copy from any side. In the center I would spread out a beautiful mosaic, such as we find in the museums, for instance, of Rome, a pavement in rich colors, representing some beautiful scene, which should be most carefully railed off, that it might not be worn or soiled by the profane tread of modern men. There should be cabinets in which there should be—but inclosed carefully with glass, so that there would be no danger of accidents—the finest specimens of the old Etruscan vases, of every size, of every shape, plain and colored, enriched with those beautiful drawings upon them which give them such rich characters, and at the same time such price; and on one side I would have collected for you some specimens of the choicest products of the excavations of Herculaneum. There should be bronze vessels of the most elegant form and the most exquisite carving, and there should be all sorts even of household utensils, such as are found there, of most beautiful shape and exquisite finish. On the walls I would have some of those paintings which have yet remained almost unharmed after being buried for so many hundred of years, and which retain their freshness, and would glow upon your walls, and clothe them with beauty, and at the same time with instruction. And then I would have a most choice cabinet, containing medals in gold and silver and bronze, of as great an extent as possible, but chiefly selected for the beauty of their workmanship; and engraved gems likewise, every one of which should, if possible, be a treasure. Now, if such a museum could be collected, you would say, I am sure, that so far as classical antiquity goes—classical art—you have everything that you could desire, and you have as noble, as splendid, as beautiful a collection of artistic objects as it is within the reach of modern wealth and influence to collect. In fact, you would say, if you could not make artists now by the study of these objects, it was a hopeless matter, because here was everything that antiquity has given us of the most beautiful.

Now, I am afraid that, while you have been following me in this

formation of an ideal museum, you have thought it required a great stretch of imagination to suppose it possible that such a collection could be made in any city of England. I will ask you, then, now to spread your wings a little more, and fly with me into even a more imaginary idea than this. Let us suppose that by some chance all these objects which we have collected were at some given period, in the first century of Christianity, collected together in an ancient Roman house; and let us suppose that the owner of the house suddenly appeared among us, and had a right to claim back all these beautiful works of art which we so highly prize, which we have taken so much trouble, and laid out so much money, to collect. Now, what does he do with them when he has got them back? What will he do with these statues which we have been copying and drawing and admiring so much? Pliny finds great fault, is very indignant with the people of his age, because he says they have begun to form galleries, *pinacothecas;* that such a thing was unknown before; that no real Roman should value a statue merely as a work of art, but that it was only as the statue of his ancestors that he ought to value them. And thus that Roman looks at them as nothing else. He takes them back; he puts the best of them, not in the center of a room where it may be admired; but to him it is a piece of household furniture, and he puts it with all its fellows into the niches from which they have been taken, and where they are, perhaps, in a very bad light. It is exceedingly probable that if the statues were not of his ancestors, he would, instead of allowing them to remain in the beautiful hall prepared for them, send them into his garden, into his villa, to stand out in the open air, and receive all the rain of heaven upon them. The mosaic which we have valued so much, and which is so wonderful a piece of work, he will put most probably into the parlor of his house to be trodden under foot by every slave that comes in and goes out. And now he looks about him at that wonderful collection of beautiful Etruscan vases which we have got together, and he recognizes them at once: "Take that to the kitchen; that is to hold oil:" "Take that to the scullery; that is for water:" "Take these plates and drinking-cups to the pantry; I shall want them for dinner." And those smaller, those beautiful vessels, which yet retain as they do the very scent of the rich odors which were kept in them, "Take them to the dressing-rooms; those are what we want on our toilet, This is a washing-basin which I have been accustomed to use. What have they been making of all these things, to put them under glass, and treat them as wonderful works of art." And, of those beautiful bronze vessels, some belong again to the kitchen, others belong to our furnished apartments; but every one of them is a mere household piece of furniture. And then he looks into the beautiful cabinet; and he sends those exquisite gems into his rooms, to be worn by his family, as ordinary rings. And your gold medals and silver medals and bronze medals he quietly puts into his purse; for, to him, they are common money. Now, then, here we have made a collection of magnificent productions

of art; and, in reality, these were all the fruits of the arts of production.

Now, what are we to say to this? We are to say that *there was a period in Rome, and there were similar periods in other countries at different times,* when there was no distinction between the arts of production and the art of design; but those very things, which to us now are objects of admiration as artistic work, were then merely things made and fashioned as we see them for the ordinary uses to which we adapt other things of perhaps similar substances, but of a very different form. For, in fact, if you had these vessels, you would not know what to do with them. We could not cook a dinner in them. We certainly could not adapt them to our common wants. But to the Romans they were the very objects which were used for those purposes; and although now, in reading the old writers, and trying to make out the dreadfully hard names by which all these different pieces of pottery are called, yet, learned and classical as all that may be, when we come to translate these high-sounding Greeks names into English, we get very modest results—pipkins and basins and ewers and flagons, and such homely names as these. Now, where is the art there? Is it that these were designed, do you think, by some man of great reputation; and then that they were all carefully copied, exactly imitated, from his design? Oh, certainly nothing of the sort. The art that is in these beautiful things is a part of themselves; is bestowed upon them in their fabrication. You may take the Etruscan vase, and you may scratch away from it, if you please, every line which had been traced by the pencil of the embellisher upon it; and, after that, the seal of beautiful design, grace, and the elegance of true art are so stamped upon it, that, if you wish to remove them, you must smash the vase. It is inherent in it; it was created with it.

Then what I fancy is desired is, that we should bring art back to that same state in which the arts of design are so interwoven with the arts of production that the one cannot be separated from the other, but everything which is made is by a certain necessity made beautiful. And this can only be when we are able to fill the minds of our artisans with true principles, until really these have pervaded their souls, and until the true feeling of art is at their *fingers'-ends.* You will see, I think, from the example which I have given you, what is the principle at which I am aiming; which I wish to establish. It is this: That at any period in which there has been a really close union between the arts of production and the arts of design, *this has resulted from the union in one person of the artist and the artisan.*

Such now is the principle that I am going to develop; and in doing so I will distinguish between arts of production belonging to two distinct classes. There are those in which necessarily there is manipulation—the use of the hand, or of such implements as the hand directly employs; and there are those in which mechanical ingenuity is employed in the art of production. It is clear that these two must be treated distinctly; and I will begin with the first, which affords the greatest

number of illustrations and examples, in proof of that principle which I have laid down.

I will begin first, then, with illustrations from metal work. Now, the period in which there was the greatest perfection in this sort of work, as is universally acknowledged, is from about the fourteenth century—1300, I think to 1600, or at least after 1500. It is singular that, in that period, five at least, very probably more—but we have it recorded of five of the most distinguished sculptors whose works are now the most highly prized, that they were ordinary working goldsmiths and silversmiths. This is given us in their respective biographies: Benvenuto Cellini, Luca della Robbia, Lorenzo Ghiberti, Brunelleschi, and Baccio Bandinelli, all of whom were goldsmiths and workers at first, developed most extraordinary talent as sculptors. How was this done? Can we conceive a person who is merely a workman, working upon such plate as is put before him, becoming a man of high first-class character in art? There have been examples, but they are rare. But here we have five men, in a limited period, becoming most eminent. Now, what was the reason of that? It was because the jeweler, the silversmith, who worked with his hands, was educated, not only as an artist, but an artist of the highest class; and Vasari observes, in the life of Bandinelli, that in those times no man was reputed a good goldsmith who was not a good draughtsman, and who could not work as well in relief. We have a principle then established, that the person who did the material work in the finer works was an artist, who could not only draw, but model, and did the same with the metal itself; for that is the nature of that class of work of which I have spoken.

Now, take the life of Cellini. Here was a man who originally was put to a totally different employment. His father had no higher ambition concerning him than that he should become a great player upon the flute; and he teased him during all the last years of his life because he had no taste for this, and would run after goldsmiths and others, and learn the different branches of their profession. He led the most wonderful life. He was to day at Rome; next day at Florence; then he was at Naples; then at Venice; then in France; then back again: that he could have done any work, in fact, seems incredible to any one who reads his life. And he did not travel by train or any public conveyance which could take on his luggage. He traveled on horseback each time, from Rome all the way to Paris. He had no luggage; he was a poor man, and whenever he came and started his shop, he began by making his own tools; and he worked with his scholars, who were generally young men that became themselves eminent in the profession, in a little open shop, looking to the street; there he himself hammered and carved and cast and shaped, and did whatever else was necessary for the work. He was an actual working goldsmith; and the beauty of his works consists in this, that they have the impress of genius so marked upon them, that they never could have been designed by one person and executed by an-

other. There is as much art in the finish by his own hand, in every enamel, in the setting of every stone, as there is in the entire design; nor does he ever dream of talking of himself in any other way; and yet how he went on from step to step, until at length he produced the most magnificent works, on the largest scale, in marble and in bronze! He describes how he constructed his own Perseus. He went to buy his own wood, and saw it brought; and when he was casting that most exquisite statue of Perseus, which is still one of the wonders of art, he had every sort of misfortune. His furnace blew up, the roof was blown off, and the rain came in torrents upon the fire just the moment that the metal was going to be poured in. By his ingenuity, his extraordinary contrivances, he baffled, it might appear, the whole chain of accidents, and brought out, almost without a flaw, that most perfect piece of workmanship. You may imagine to what a state he was reduced, when, the very moment that the metal was ready for pouring out, the explosion took place. He had no other resource but to run to his kitchen, as he says, and to take every piece of copper, to the amount of two hundred porringers and different sorts of kettles, and throw them into the fire; and from these that splendid statue came forth. There was genius.

As a curious instance of the most extraordinary ingenuity, he tells us that on one occasion a surgeon came into his shop to perform an operation on the hand of one of his pupils. Upon looking at his instruments, he found them, as they were in those days, so exceedingly rude and clumsy, that he said, "If you will only wait half an hour, I will make you a better instrument;" and he went into his workshop, and took a piece of steel, and brought out a most beautifully finished knife, with which the operation was successfully performed, Now this man, at the time you see him thus working in his shop as a common workman, was modeling in the most exquisite manner in wax; spending his evenings in the private apartments of the Grand Duke, modeling in his presence, and assisting him with a hundred little trifles which are now considered treasures of art. And so wherever he was, and under all circumstances, he acted as an artist, but at the same time as a truly laboring artisan. It was the same with others in the same profession. He was not the only man, by any means, whose genius was so universal; because we find him telling us repeatedly that the moment he heard of some goldsmith (and in those days a goldsmith was really an artist, as I have already said) who excelled in any particular branch of art, he determined to excel him. Thus it was that he grew to rival the medals of one, the enamels of another, the peculiar manner of putting foil to precious stones of another; and, in fact, there was not a branch of art which he did not consider it his duty to excel in. With this spirit, is it wonderful that men of really great taste should have been produced? men who, you observe, looked upon every branch of productive art as really a branch of the higher art of design; and thus in their own persons combined that art with the power of the tool; were artists as well as artisans.

There is another celebrated jeweler of that time, whom he mentions frequently, of the name of Antonio Foppo, a Milanese, who is better known in the history of art by a name which he received in derision in Spain, the name of Capodursa, which means a bear's face, and which he is known by, commonly, in works of art. Cellini describes to us the processes by which he produces his works; and they are so careful, and require such accurate knowledge of art, that his knowledge must have been very superior indeed in the arts of design. As an instance of what was the latitude and the extent of art, and how really a jeweler or goldsmith in those days was not above work which in our days no one would dare offer to a person of such a profession, we have a case recorded in the history of one of the painters, Pierino del Vaga, by Vasari, speaking of a very particular friend of Pierino's, a goldsmith. When the Grand Duke of Tuscany was building his palace, he gave to this man a commission to make the metal blinds for the ground floor of that palace; (and it is considered a great pity that a work of so homely a nature should have perished, because there can be no doubt whatever that it was a work of exquisite beauty.) So that, even upon what would be considered the lowest stage of common production, the artist did not feel it was beneath him to design; not to give a design to others, but to execute it himself. We have in the collections, particularly of Italy, in the palaces, evident proofs of the great extent to which this combination of various arts must have been carried, in works exceedingly complicated, extremely beautiful, and at the same time necessarily requiring a great deal of ability to execute. Those are the rich cabinets in which may be found, mixed together, work in marble, and in ivory, in wood, in metals, in enamel, and in painting, all combined together by one idea, and all executed by one hand, but of the authors of which it seems impossible to find any good trace. They probably were produced by those men called goldsmiths, and who, as I said before, could work as well upon any of those substances, and thus bring them harmoniously to form one beautiful whole.

Now, proceeding from what is most precious in art to what is more homely, let us return for a moment to a subject on which I have already touched. I have spoken of the beauty of the productions of antiquity in metal, which were found in the excavation particularly of those two buried museums, as we may call them, of antiquity, Pompeii and Herculaneum. The collection of these is chiefly in Naples. Except where presents have been made to other countries, they have been jealously kept together. Now, these different objects have not been dug out of temples or out of palaces, but they have been taken out of every sort of house—houses evidently belonging to the citizens—and I think you may see that there is not one in that collection which does not immediately arrest the eye both by the beauty of form and by its exquisite fancy. Many of them have been engraved in the publication called the "Museo Borbonico," the Bourbon Museum, the Museum

of Naples; and I think very justly the remark is made by the editor in the fifth volume, that the whole modern civilized world, however vast it may be, and however it may labor in so many arts and so many trades, does not and cannot exhibit even a small proportion of that elegance and ornament, varied in a thousand ways, and in innumerable most fantastic modes, which are to be admired in the remains of furniture found in Pompeii and Herculaneum—two cities which occupied so insignificant a place in the ancient world. That is quite true. Now, what are we to infer from this? There can be no doubt, as I have said, on examining these beautiful objects, that they have been for common use. There are scales, steelyards, which can only have been made to weigh provisions; the chains are most delicately worked; the weight is frequently a head with a helmet, most beautifully chiseled; and so genuine and true are these, so really intended for every-day use, that one of them has stamped upon it yet, the authentication made at the capitol of the weights being just. This was a steelyard which was in the kitchen, and it was for the ordinary purposes of the house. There are other large vessels which must have served for culinary purposes, and of which the handles and the rings and the different parts are finished far beyond what the finest bronzes that are made now in Paris can equal. What are we to conclude? You do not suppose these were the designs of the Flaxmans and the Baileys of that day. Who ever heard of a great artist in Pompeii and Herculaneum? And how can you imagine that every house furnished itself with what were considered exquisite and extraordinary specimens of art for the use of their every-day life? And then, where are their common utensils, if these are not they? If these lamps were not what they burnt, if these candelabra were not the shafts upon which they were hung, if these vessels were not those in which they prepared their viands, where are those? Were they carried away in the flight? But the most precious would surely be carried away, and the commoner be left behind. Nothing of the sort. One may see here everything is to be found; and everything is beautiful in shape, and generally in finish. What are we to conclude? Why, nothing less than that the braziers who made these things were able to make them. They came from the hands of the brass-founder; they have been chiseled in the workshop; they have been finished, not to be put up in cabinets, but in order to be knocked about by servants. Then here we have a state of art in which the producer, the man who makes, who manipulates, who handles the object of manufacture which he produces, was able to do what now defies almost our most superior workmen.

Now let us go to another part of the world, and come to a later period. Nuremberg, during the time which I have specified—between 1300 and the middle of 1500—was a center of art, and especially in all metal work. There is an observation of Hoffman, a German writer, that Nuremberg was the city in which the artist and the crafts-

man walked most harmoniously hand in hand; but I think he does not go far enough; he ought to have said that it was a city in which *the artisan and the artist were the most perfectly combined.* At a very early period, that is, as early as 1355, there was produced a piece of work such as is at this day the admiration of all artists. And what was it? It was a mere well, a fountain in the public square; "the beautiful fountain," "the beautiful well," as it is to this day most justly called. Now, this was made entirely by the designer, by the artist himself, Höfer, who united in himself these two qualities; and it is acknowledged that in the treatment of the metal work, and in the beauty of the religious images which surround this fountain, but few steps have been made in art since that time. And he, as I observed, was a mere workman; he did his own work. At a later period—at what is considered the third period of art, in Nuremberg—there is another remarkable piece of metal work; and I am glad to find that in the last report just published by the department of practical art, Mr. Smirke has introduced a letter in which he begs that this piece of workmanship, which he calls one of the most celebrated productions in metal, may be copied by casts, and brought to England as a specimen of art. Now that beautiful production was of as early a period as 1506; it was made between 1506 and 1519, and it is the shrine of St. Sebald, in his church at Nuremberg; an exquisite piece of work—so beautiful, so elegant, as that no iconoclasm had dared to touch it (though I must say that Nuremberg had been preserved from the reproach of that error)—but there it is, in its freshness and its beauty as it came from the artist's hand; in the center, a shrine of silver, in which is the body of the saint, and around it what may be called a cage or grating of the most perfect metal work, and with statues of most exquisite workmanship. Now I do wish this to be brought to England—a copy, that is, of it—not merely because it will show what was done in ages that we consider hardly emerging from barbarism; not only what beautiful inspirations religion could give the artist; but because it will show to those who are trying to raise the character of any art *the true principle upon which alone it can ever be raised to what it was then.* They will see the artist portrayed upon it—Peter Vischer; they will see him with his apron on; they will see him with his chisel and his mallet in his hand; they will see that he aspires to nothing more than to be a handicraftsman, a workman in metal, who yet could conceive, and then design, this most magnificent production of man's hand.

Another example, something of the same sort, we shall find in a neighboring country. There is at Antwerp, likewise, a beautiful well near the cathedral; and if you ask who it was that produced this, you will hear that it was one who sometimes had been known as a painter, and at others, under the more familiar appellation of the "Blacksmith of Antwerp," as a blacksmith; and there is a piece of iron-work which I fear that not our most perfect works could turn out—certainly not, nothing that could be compared with it. And Quintin Matsys was

a poor school-boy, who, finding the heavy blacksmith's work too much for him, took to drawing and coloring little images of saints, to be given out in processions, and thus rose to be a painter and an artist, finding his first profession too heavy for his strength. But this iron-work is a work of art; it is not a work merely cast in the lump, and then put together; but it is a work that required genius, that required great artistic skill; it shows that the artist even worked in iron; that a man who belonged to the very lowest branch of what may be considered the arts—laboring in metal—was able, notwithstanding, to imagine and to carry out the most beautiful conceptions.

Now, coming to modern times, do we find anything of this sort? I content myself with referring to that last report which I have just mentioned—of the department of practical art. In that report there are incorporated letters from some of our best silver and goldsmiths upon the character of the artistic proficiency of the workmen. I will only read one, for all in reality repeat the same sentiment. "At present we seldom find an English workman who understands drawing. Not one of our English workmen has a knowledge of drawing;" and it is said that, without exception, these men will not even go to the school. Attempts have been made to bring them to the school of practical art, that they may learn something of the principles by which the works in their branch of productive art should be conducted. They cannot be induced to go and obtain that information, though it is nearly, or entirely, gratuitously given. So little taste, so little feeling of art is there in our workmen now. Can we expect they will produce works that will rival those of ancient times? For there is this broad, immense difference: in one, the artist was the workman; now, the workman has only a degree of intelligence above the machinery which he uses. He can apply those means which are put into his hand; but can have no artistic feeling to give the last touch, or even to bring things to ordinary perfection. On the other hand, we must be struck with the difference, that in France there is much more taste, much more knowledge, much more intelligence, in the actual artificer; the exhibition showed, that, though we had magnificent things in silver-work, and gorgeous objects in metallic productions, beautiful and splendid, yet, when you came to look at them with the artist's eye, you could not help observing the immense difference between our English productions and those of France; though, be it spoken to the glory of our English goldsmiths, they have both the taste and the generosity and munificence to bring over and to employ the very first foreign artists; and it was thus we did produce some objects that stood in competition, not with those of the workman's rivals, but with those of his own countrymen.

In Vecht there is an example of what the artists in old times were. He began as a cotton-spinner; he became a manufacturer of toys; then a button-maker; and then he began to work with the chisel. His genius developed itself. He began to retouch and repair ancient armor,

and then was tempted, seeing that these were things sought after, (it appears with the most honest intention,) to imitate them; and he found that they were bought and put in royal and imperial cabinets as real work of what is called cinquecento. And then he imitated the shields, working exactly upon Cellini's principle, that everything, however small, is worked out separately, and then fastened together; that nothing is cast, but that everything, to the smallest tip of the least finger, is hollow; and he worked on, and produced it by his artistic and careful manipulation. He began to work this way, and he found his silver-work also became considered as ancient, and was adopted into collections of valuable antiquities. He then learned the power of his own genius, and he soon rose; and, when the late revolution in France took place, he had commissions for works to the amount of £60,000. And this was all *his own* work, the production of *his own* hands. However, his losses were in common with many others who had engaged in higher branches of art, and he has been since in this country; but certainly those specimens of his work which we had in the exhibition were not only most beautiful, but most exquisite; and many persons who took the pains to examine in detail some of the works in silver, which were presented by one French house in particular—the Frères Maurice—must have been struck by the high artistic merit of them all. And they all are worked entirely bit by bit by the artist; and it was impossible they could be executed but by an artist who could model as well as draw, and who knew how to treat his metal perfectly, so as to give all the softness, beauty, and delicacy of the original model.

Now let us proceed to what may be considered a higher branch of art, and that is sculpture. We shall find exactly the same principle throughout; all the greatest artists of the most flourishing period were *men who did their own work.* You are probably aware—many, I have no doubt, are—at the present day, when a sculptor has to produce a statue he first of all makes his model in clay; probably a drawing first, then a small model, then a model exactly as he intends the statue to be, full-sized and completely finished; from this the cast is taken in plaster; the block of marble of proper size is put beside it, and a frame over it from which there hang threads with weights; these form the points from which the workman measures, from corresponding lines, first to the models, and then from these which are over the cast to the cast itself; and by means of the merest mechanical process he gradually cuts away the marble to the shape of his cast, and often brings it so near to the finished work that the artist himself barely spends a few weeks upon it. This was so much the case with a very eminent sculptor that it is well known he hardly ever had occasion to touch it.

Now that was not the way the ancients worked: they knew perfectly well that there was more feeling in the few touches which the master-hand gives, even from the very beginning of the work, than there can be in the low and plodding process of mechanical labor; and we find that

those who were really exquisite sculptors in ancient times *were also their own workmen.* Vasari tells us of Orcagna, that he made at Florence seven figures, *all with his own hand,* in marble, which yet exist. Now, Orcagna was certainly a remarkable person. He was a sculptor, painter and an artist: and so justly *vain,* if one may so speak, of this varied character of his art, that, upon his monuments or sculptures, he calls himself a painter; upon his paintings, he always calls himself a sculptor. His paintings are to be found in the cemetery at Pisa. The most beautiful and splendid of his works is the matchless altar in the church at San Michael, in Florence, of which, I am glad to say, there will be an exact copy in the future Crystal Palace. This artist, now, whose work is certainly most beautiful, most finished, as far as we can gather from his life, *actually did the work with his own hands, and carved the whole of the marble himself.*

I shall have occasion to speak of another celebrated artist under another head; and therefore I now will mention one who became very celebrated, and from whose life it is evident that he did the whole of the carving with his own hands, and that is Brunelleschi. He lived at the period when art was becoming truly most beautiful—the period which just preceded the appearance, perhaps, of a still greater artist, but who, in some respects, departed from the purest principles of art. He was the contemporary of Donatello, and they were both very great friends, and worked even in the same church. An anecdote related by Vasari, in the life of Donatello, will show us how truly Brunelleschi was not merely a sculptor, but a carver who performed the work with his own hand. He tells us that Donatello had received a commission to carve a crucifix, (which yet exists in the church of Santa Croce, under a beautiful painting by Taddeo Gaddi,) and that he produced what was considered a very fine work; but he was anxious that his friend Brunelleschi should see and approve of it. He invited him therefore, one day, to inspect it; which shows that the work had been covered up and concealed during the execution. Brunelleschi looked at it, and said nothing. His friend Donatello felt hurt, and said, "I have brought you here to give me your opinion; tell me candidly what do you think of it?" "Well, then," Brunelleschi said, "I will tell you, at once, that it is a figure, not of Christ, but of a peasant or a rustic." Donatello was indignant. It was perhaps the most beautiful specimen of the subject in carving that had been produced; and he used an expression which became a proverb; and I cannot help remarking how many expressions of artists have turned into proverbs. The expression in Italian means this: "Take a piece of wood, and make another." Brunelleschi did not reply. He went home. He did take a piece of wood. He said nothing to Donatello, and he carved his crucifix. When it was quite finished, he met Donatello, and said, "Will you come and sup with me this evening?" (Now I narrate this anecdote partly because it shows us what the great artists were—that they were not great gentlemen living in any

particular style.) "I will do so with pleasure," said Donatello. "Then come along;" and Brunelleschi, as they went on, stopped at the market, bought eggs and cheese for their supper, put them in an apron, and said to Donatello, "Now, you carry these to my house while I buy something else, and I'll follow you." Donatello entered the room, saw the crucifix, let fall his apron, and smashed the eggs. Brunelleschi soon followed, and found Donatello with his hands stretched out, and his mouth open, looking at this wonderful work. "Come," said he to Donatello, "where's our supper?" "I have had my supper," said he; "you get what you can out of what is left." And then, like a true, noble-hearted, generous artist, he took his friend by the hand, and said, "You are made to represent Christ; I, only to represent peasants." Now, this shows, as I said before, that this poor artist carried on his own work with his own hands, shut up in his own house; in fact, that, as Vasari tells us, he never allowed any one to see it until it was quite completed.

There can be no doubt that, among all the names celebrated in art, there is not one that can be put in comparison with that of Michael Angelo; a man who, not merely from his follower, disciple, and intimate, Vasari, but even from jealous and envious and ill-tempered Benvenuto Cellini, receives constantly the epithet of "the divine." No man certainly ever had such a wonderful soul for art, in every department: the cupola of St. Peter's, as an architect; his Moses and his Christ, as a sculptor; and his Last Judgment, on the ceiling of the Sistine Chapel, as a painter, are three monuments which would have made the eternal fame, not of three, but of a hundred, artists in each department. Great, noble, generous, and though perhaps somewhat in his temper not amiable, yet sternly honest in all his dealings, he seems to have been the great center around which the art of his period revolved. There was no one so great, so sublime in any particular branch of it, that did not look up to Michael Angelo, and consider him his superior. It is acknowledged that Raffaelle went into the Sistine Chapel, and saw Angelo's wonderful works, and changed entirely his style upon beholding them; and it is particularly acknowledged by the writers of that time, that in every other department—civil engineering, &c.—he was considered equally supreme. Now, you would suppose that this man, upon whom commissions poured in every day for great works, would have employed a number of artisans to assist him; that he would have had carefully prepared models, which he would have intrusted to skillful artificers, so as to lighten his labor. But no such thing. There is every evidence we can desire, that, from the beginning to the end, Michael Angelo performed the whole of his own work; that he began with the piece of marble as it came from the quarry; that, if not always, pretty generally, he did not even condescend to make a design beyond a small wax model, but immediately set to work with chisel and mallet on the figure which he had in his imagination, and which he knew was as truly lurking in the inanimate block. Vasari shows us, in fact, from his unfin-

ished pieces, in what way he must have mapped out the marble and done the work himself; and that is why we have so many vast pieces by him unfinished: either the stroke did not come out as he desired, or it went too far into the marble, and spoilt his labor. But so it is, that by far the greater part of those gigantic pieces which he finished, if not all, were the productions of his own hand, as well as of his intellect.

When about seventy-five years of age, Vasari tells us, he used to be just as indefatigable with his chisel and hammer as when he was a stout, young man. He had near his bed-room, if not in it, (for he lived in a most primitive and simple manner,) an immense block of marble, and, when he had nothing else to do, he used to be hammering at that; and when asked why he so continuously worked at this branch of his various arts, he used to reply that he did it for amusement, to pass his time, and that it was good for his health to take exercise with the mallet. He undertook at that age, out of an enormous block of marble, to bring out four figures, larger than life, representing the descent from the cross; and he had nearly worked out the figure of our Lord, when, happening to meet with a vein that was hard and troublesome, he one day broke it into half a dozen pieces. It was seen in this state by a friend, and his servant begged it for him. It was put together, and it is now to be seen at Florence. But Vasari says that it was necessary, in order to give him occupation, to get another large block of marble and put it near his bed, that so he might continue at his work; and he began another group of the same sort. This was at the age of seventy-five. And Vasari gives us an interesting account of how he worked: he says he was remarkably sober, and while performing his greatest works, such as the paintings, he rarely took more than a crust of bread and a glass of wine for his dinner. This sobriety, he says, made him very vigilant, and not require much sleep; and very often in the night he used to rise, when he could not sleep, and work away with his chisel, having made for himself a sort of helmet, or cap, out of pasteboard, and upon the middle of this, in the top, he had his candle, so that the shadow of his body never could be thrown upon the work.

Apropos of this, Vasari tells us an anecdote which is interesting as showing the character of Michael Angelo and of his time. Vasari observes that he never used wax candles for this purpose, but a particular sort of candles made of goat's tallow, which, he says, are particularly excellent. Wishing to make him a present, he (Vasari) sent to Michael Angelo his servant one day with four bags of these particular candles, containing forty pounds of them. The servant brought them; and Michael Angelo, who never accepted a present, told him to take them back again, he would not receive them. The servant said, "They have nearly broken my arm in bringing them, and I shall not carry them back." "Then do what you like with them," said Michael Angelo. "Then," replied the servant, "I observed, as I came to your house, that just before your door there was a nice bed of just-hardened mud: I'll go

and stick all the candles in this, and light them all, and leave them there." Michael Angelo said, "No, I can't allow you to make such a confusion as there would be about my door; so you may leave them." This shows the homely and friendly way in which the artists lived among themselves.

We have a very interesting account of the manner in which he used to work at his marble, from a contemporary French writer, who says: "I can say that I have seen Michael Angelo, when he was about sixty years of age, and not then very robust, make the fragments of marble fly about at such a rate, that he cut off more in a quarter of an hour than three strong young men could have done in an hour—" a thing almost incredible to any one who has not seen it; and he used to work with such fury, with such an impetus, that it was feared he would dash the whole marble to pieces, making at each stroke chips, of three or four fingers' thick, fly off into the air;" and that with a material in which, if he had gone only a hair's-breadth too far, he would totally have destroyed the work, which could not be restored like plaster or clay.

Going now to another part of the world for the same art, we return to Nuremberg, and find a most magnificent piece of sculpture in stone, unrivaled in the delicacy and exquisite beauty of the work; that is the tabernacle in the church of St. Lawrence. It rises from the ground and goes up, not merely to the top of a very high church, running along like a plant, with one of the pillars against which it is built; but, as if the church was not high enough for it, creeping far beyond, and making the most graceful termination, which has nothing similar in works of this sort. So beautiful and delicate is the whole work, representing all the mysteries of our Lord's life and passion, that, for a long time, people used to assert that it was not stone, but modeled in some composition. But it has been proved beyond doubt that it is stone. Now, the man who made this was a mason—*a common working stone-mason*—Adam Kraft, who built part of the tower of the church, and whose name is upon it as the mason who built it; and he, until 1490, when he was fifty-three years of age, had never attempted to work as a sculptor; and yet, before he died, he had not only executed many beautiful works, and among them a carved staircase in the tower, but this exquisite work, which is without a parallel. He has represented the whole of it as supported by three kneeling figures, himself and his two apprentices, who executed alone the whole work.

We see, therefore, that wherever there has really been grand or noble work executed by sculptors, *they have been artificers as well as designers; they have done the work with their own hands, as well as imagined it in their own fancies.*

Let us go now to another department of art. We have treated of metals and carved work in wood and stone. Let us now go to pottery. I have already observed that those beautiful vases, known by the name of Etruscan, were really made originally for domestic use; that, consequently,

they were made by the potter, and not by a fine artist only. This has been fully proved. It used to be thought at one time that they were all funereal, or of symbolical use, being found almost entirely in tombs; but it has been proved that the greater part of them were for the common domestic purposes of the table and the household; that some, indeed, were given as prizes at the games, filled with oil; others were marriage presents, kept with more care in houses, but still they were the work of the potter, and must have been produced entirely by hand. Pottery was so much considered as a branch of art, that in early Rome, in the time of Numa, there was a college of potters; they were ennobled by being made a special guild. Any one who went through the exhibition must have been particularly struck with the elegance of forms which prevailed in all the Indian and also in the Turkish pottery; and the common vessels, used to carry water on the head by the peasantry of Italy and Spain, have the same elegance of form which very little of our china, or of our finest pottery, can exhibit; and the question naturally suggests itself, how is this, that in many countries there should be such beautiful productions, and at the same time that we should not be able to give the same beauty of form? The answer to this is given, I think, very correctly by Mr. Digby Wyatt, in his beautiful work on the late exhibition. He observes that "there can be no doubt that the reason of this beauty in the old pottery and in that of the East is, that *it is made entirely by the workman himself.*" There can be little doubt that the most beautiful forms of Greek and Etruscan vases have been generated by a simple process of formation, and by the refined delicacy of touch acquired by the potter during *years of practice.* The perfect outline of some of the commonest objects of pottery from India, Tunis, Turkey, and the rest, demonstrate the methods by which contours equal in grace to the Etrurian and those of Magna Græcia have been produced. In the finer work of pottery among us, a distinct person is employed to design from him who makes the object; the one makes the pattern, and a mold is then made of the same figure as is given. But in the ancient and oriental objects, the beauty of form is attributed to *the art being literally in the potter's fingers;* and he acquires by the manipulation a fineness of touch, a delicacy of eye, which enables him to produce beautiful forms, which *no one in the abstract* could imagine." This is corroborated by the fact that in the British Museum, in the great gallery where the Etruscan vases are kept, you will find two—and if you search the Vatican and Bourbon Museum, and all the collections in Europe, you will not find two—perfectly alike; there is a difference in them, which shows they were not produced by a model, but simply out of hand; and I have no doubt that the influence of this working in clay without a pattern is to be traced in all the works in metal and in glass of the ancients; because, no doubt, the eye of the man who worked in bronze had been formed by his familiarity with the beautiful patterns which came forth every day from the hands of the workmen in clay. I find, too, it is mentioned

in Pliny, that when a knight named Octavius, in the time of Augustus, wished to have a vase made, it cost him a talent, or upwards of £50, to have the model made; which shows that the clay model was to be modeled before the marble vase was sculptured. In this art, then, the producer is the designer, the artist is the artisan, *and hence comes perfect beauty.*

Next to this must be mentioned a very important branch of productive art, in which the art of design is always necessary to be in combination with the actual manufacture; and that is china, or painting upon pottery. The Etruscan vases are often simple, sometimes of one color, sometimes they have nothing of ornament; at other times they have most beautifully executed, though sketchy, scenes of ancient mythology, or very frequently from the "Iliad." These are done in a way which shows there must have been hundreds of artists who could do that work. Very frequently it was not a painter who did them, but the man who was at work on the pottery throughout; and, although mere sketches, they are considered as containing the elements of very beautiful drawing. If we come to speak of the art of modern times, a remarkable instance of genius persevering in its work may be taken from the history of Bernard Pallissy. He was an artist, but as a painter of comparatively humble pretensions; for he tells us he used to paint figures, images, and so on; but in this he was an artist, to a certain extent. He tell us himself, in the biography he has written, that in 1544, when there seemed not to have been anything approaching to ornamental pottery in France, he happened to see an Italian cup, which struck him as being very beautiful; and he thought to himself, "Why could not this be produced in France?" He set to work. He was a poor man, hardly educated; but he had a great turn for chemistry, and was particularly desirous of finding out a manner of enameling pottery, and especially a white enamel, which he at length contrived to make. He took his worked to be baked in glass-houses, and found it completely fail; then he set to work in his own house, and built a furnace for the purpose. He put his ingredients into the furnace; they would not set nor harden. He had spent all his money, and he gradually pawned all his clothes, and burnt every article of furniture, to keep up the furnace, and pulled up the fruit trees in his garden, and then the very floor of the house, to keep up the fire. Still the work was all spoiled. When he went out the people charged him with being a coiner; he was ridiculed as mad; and every sort of annoyance came on him. He persevered yet; and, having found that his furnace would not act, he pulled it down, and with his own hands bringing the lime and bricks, he built another furnace, and then sat for six days and nights watching the fire. Then he got a little money by having a commission to make a survey, and came back to his work, and tried again. The mortar he used, however, happened to have some deficiency in it; and, just as the pottery was going to set, he heard a crack, and the pebbles in the mortar began to fly and broke

his enamel. He set to work again, and put his materials again in the fire; and this time there was a tremendous explosion, the ashes burst in and the whole of his work was covered with black, so firmly set into the enamel that it all had to be thrown away except a few pieces, by which he made a trifle. For sixteen years he persevered in this way, and then was crowned with success, and produced the finest specimens of colored and beautiful pottery, such as are to this day sought by the curious; and he received a situation in the king's household, and ended his days in comfort and respectability.

I could mention the beautiful earthenware of the sixteenth century, known by the name of "Raphael's ware," because it is supposed that Raphael himself did not disdain to make designs for common pottery, pottery not to be used merely by the rich, but to be found in the common cottages and houses of ordinary classes; the most beautiful specimens being in the apothecaries' shops of Padua and Verona. There we have the employment of high art in the decoration of a common and ordinary object; for the pottery itself has no particular pretensions to elegance of make, but yet one of these plates, thick, heavy, clumsy, and coarse as they are, is worth a service of modern production as a work of art.

Another department is statuary in pottery, which presents some very interesting features in the history of art. Its very origin is exceedingly interesting. Pliny gives it to us as the invention of a certain potter, of very ancient date, whose daughter, when parting with a youth to whom she was engaged, did what I dare say some of you have done, made him stand before the lamp, so as to throw his shadow on the wall, and so sketch his head and face; and the father, wishing to preserve this sketch, took some of his clay, and filled up the outline, and made a bass-relief of the countenance. That piece of pottery, at the time when the Romans first became acquainted with art, and carried away the monuments of Greece, was preserved in the temple of the Nymphs, at Corinth, as a treasure of art—as the first germ from which had been developed some of the most beautiful productions of that kind. At the time of the Roman kings of the race of Tarquin, the inhabitants of Italy had arrived at such perfection in this art that they used to make chariots, horses, and other representations of clay, so well baked that they could be placed in the open air, and stood for many centuries without injury; and, in fact, we find them now among Etruscan monuments. The Romans must also have learned well how to paint them; because we find it stated that there was an artist, whom Varro particularly mentions, who imitated fruit in pottery so perfectly as to deceive any one, and make one think it was real.

But the most interesting example of this application of high art to such products is what we find in the life of an eminent artist, and at the same time a potter, Luca della Robbia. He was put, when quite a boy, apprentice to a jeweler. He very soon began to make things in bronze; he gave up mere small modeling, and began upon marble, and succeeded

very well. He worked the whole of the day at his chiseling, and sat up all the night drawing. He was poor; he was hungry and cold; and the only means he had of warming himself at night was to put his feet in a basket of shavings, while he sat there drawing, and would not be driven from it. Now, there was an education for him, beginning first with small work, and exercising his patience and skill in that way. Sigismund Malatesta, the great patron of art at Rimini, was then building a splendid church, and he sent to Florence to find workmen to do the carving; and Luca della Robbia was engaged for this purpose. He had at that time been a silversmith's apprentice, had executed works in marble and bronze, and was set to undertake that noble work at Rimini; and how old was he when Sigismund engaged him? He was *fifteen!* And what pains and study must have been gone through in that time by the poor boy to make himself really an artist! He succeeded admirably at Rimini, and came back and received a commission to work with Donatello, to make a screen for an organ, and a bronze door. After all this, he suddenly discovered a totally new branch of art—modeling in pottery. He first contrived to manufacture his own clay; he then discovered a mode of glazing it to such perfection that centuries of weather do not in the least affect it. He then contrived to color it in the most beautiful manner; and all Florence, and every part of Italy, may be said to be filled with works of art equal to anything produced in marble, and valued as high. He went on improving his art; he began, then, tesselated pavements, and outsides of churches, which are most beautiful; and then, taking to himself, not a number of workmen to mold under him, but two near relatives of his, who were also artists and sculptors in marble, and who had left marble to come to work in clay, this family carried on the same work to the third generation, when the secret of the art expired with the family. But in those three generations, till Pope Leo gave the commission of making the pavement of the Loggie Raffaelle, this family made an infinite number of original works of art, executed by hand, colored and baked by themselves. Now, there is a whole family of artists, in whom the productive and artistic skill were united. In our estimation we should say what a descent that was for a sculptor in bronze and marble to come to a mere potter! But I will read to you Vasari's sentiments on that subject, who, as the great biographer of artists, and who lived among artists, and was himself an artist, may be allowed to have a right sentiment upon it. He says: "Luke therefore, passing from one sort of work to another, from marble to bronze, and from bronze to clay, did so, not from any idleness, nor from being, like many others, capricious, unstable, and discontented with his art, but because he felt himself drawn to new pursuits, and to an art requiring less labor and time, and rendering him more gain; hence the world and the arts of design became enriched with an art, new, useful, and most beautiful; and he, with glory and praise, immortal and unfailing."

We are told by Pliny that it was in the time of Augustus the prac-

tice was introduced of painting the walls of houses. Temples were undoubtedly painted before; because he tells us, that, when the temple of Ceres was falling into ruins, the paintings of Demophilus were cut away from the walls, (as is sometimes now done with frescoes,) and put into frames in order to preserve them. On one occasion, by the way, the city of Rhodes was saved, when Demetrius besieged it, because he feared a beautiful painting would be destroyed that was on the wall of one of the buildings. This painting of walls corresponded to our paper-hangings. What we do by putting on stained or colored paper, they did with the brush and the skill of the artist. The walls of Pompeii and Herculaneum are covered with most beautiful paintings, not merely ornamental patterns and arabesques, but there is such a mixture of the mere ornament, and of figures perfectly designed and colored, as to show that there was no distinction made then between the painter of a fresco and the house decorator; *the artist was himself the performer of the work*, and so beautiful is it, that we have hardly anything in modern times superior to what is commonly found on the walls of the private houses of cities which were in a province remote from the capital, and which had no particular recommendation, that we know of, as seats of art.

We have an instance, also, in modern times. Perhaps one of the most beautiful productions of modern art is the painting of that gallery to which I have alluded, where we see that *Raffaelle undertakes to do what now one would never think of committing to the hands of any one higher than a common house-decorator*. No nobleman, nor even a monarch, would think of asking the first artist of the kingdom to design the ornament of a gallery, scroll-work, and grotesques, or mechanical ornament, which now would be done by a common process or a common hand. But in a former age there was no distinction made between what we now consider the higher and the lower sorts of art; *but the whole of art was regarded as one thing;* the greatest of artists considered it was his place to make even the smallest work—which might be insignificant in itself—great and noble, and to stamp the highest impress of art on the commonest and most ordinary commissions that were given to him.

I will now speak of a department of art which will interest you, perhaps, more than others—art applied to textile fabrics. There is a great difference between what art can do in this department, and what it can do for those through which I have passed; because the others are in their nature more lasting; they are to continue for a time; they are worth, therefore, the attention and care of artists of the very highest class. The fashions of textile fabrics are perishable and fragile; they are capricious and changeable; therefore it is impossible to have the time, the leisure, and the same degree of labor expended on them as is necessary to produce a great work of art. I have read with considerable pleasure, and can bear testimony to the important suggestions in a pamphlet or lecture on this subject delivered in this city by Mr.

Potter. He is quite correct in his estimate of the somewhat exaggerated ideas which may exist of the power of art in connection with that which is not durable, and which, in reality, has its value, necessarily, for only a brief period. I agree, therefore, with him on that subject; but at the same time I accept as very important his concession that, even with regard to that degree of art which is compatible with the nature of the substance on which it is to be displayed, we do *not* do what we ought to do, and that we fall short of our neighbors, the French; or at least, that, while in that which is of secondary character we have put forth such perseverance and study as to have attained an equality with them, there is a point *in that which is more delicate and perfect* which we have not reached. This is an important concession. It appears there is some reason why, in France, they can produce, even in printed fabrics, a superior and more delicate artistic effect than can as yet be given here; and I shall have to speak of the reason of this, which accords completely with what I have said, because in these works, which are not made absolutely by handicraft, but with the assistance of mechanical skill, there *must* be a distinction between the designer and the mere workman—a man who keeps the machine in motion, and puts the work through it; although, no doubt, it is necessary for the designer also to have a considerable acquaintance with the process by which his design is to be brought out in actual manufacture. I only wish to observe how the principle comes down here. You know the cartoons at Hampton Court, the most perfect and finished work of art of Raffaelle. You would suppose these would be a labor of years, for they are all by his own hand, perhaps hardly aided by a disciple; and nothing can be more perfect than the outline and artistic distribution of the parts of the painting. What were these cartoons? Simply drawings for the loom. *Raffaelle did not think it below him to draw patterns which were to be sent to Holland or Belgium, and there to be executed in the loom by weavers of a carpet.* This shows how the very highest ideal art may bend without degradation to assist practical art with all its powers and resources; and where the union of the two in the same person cannot be got, then we have to think of the means by which the harmonious combination of both may be brought to produce one effect. While upon this subject, I am tempted to quote some beautiful lines upon the subject from one of our oldest but wisest poets; one who calls himself, upon his tomb, "the servant of Queen Elizabeth, the councilor of King James, and the friend of Sir Philip Sidney," Lord Brooke. Speaking as if it was considered in those days that the impulses of industry must be entirely regulated by the ruling power, he prescribes the duty of that in regard to the production of manufactures:

> "To which end, power must nurseries erect,
> And those trades cherish which use many hands;
> Yet such as more by pains than skill effect,
> And so by spirits more than vigor stand;
> Whereby each creature may itself sustain,
> And who excel, add honor to their gain."

Another remark I will read, which comes in the same passage, because it seems as, written in that age, prophetic of what may be considered the characteristic commercial policy of this day—that policy which particularly owes, if not its origin, certainly its greatest impulse, to this city of Manchester. He says:

"Now, though wise kings do by advantage play
With other states, by setting tax on toys,
Which, if needs do permit, they justly may,
As punishment for that vice which destroys,
To real things yet must they careful be,
Here and abroad, to keep them custom free;
Providing clothes and food no burden bear,
Then, equally distributing of trade,
So as no one rule what we eat or wear,
Or any town the gulf of all be made;
For, though from few wealth soon be had and known,
And still the rich kept servile by their own,
Yet no one city rich, or exchequer full,
Gives states such credit, strength, or reputation,
As that far-seeing, long-breathed wisdom will,
Which, by the well disposing of creation,
Breathes universal wealth, gives all content,
Is both the mine and scale of government."

Now, gentlemen, I wish to come to some general results. We have seen, that so far, in every instance we have examined, *wherever there has been real beauty and perfection of work, it has been in consequence of the practical art, and of the fine art, which ought to work together, being most closely combined, and, as nearly as it can be done, in the same individual*, or else in the most perfectly harmonious coöperation. Now, we must watch very carefully whether the plans which are being proposed for artistic education—to be applied to production—will tend to combine these two characters better, or further to separate them. I come to the conclusion, that if art has always flourished in its perfection when the two have been combined; and if, on the other hand, it is acknowledged that at present art is not applied to manufactures as it might be, and if it is, at the same time, the clearly visible fact that our artisans and workmen are not artists—I think I have a right to conclude that *this separation of the two characters is the cause of our inferiority, and that, therefore, the education which we are to prepare for those who are to carry productive art to its perfection must be one which will combine, closer than is now done, these two departments of what I consider one and the same thing*, Now, is it or can it be so by the education we are now giving? I observed that what I have said till now has been acknowledged long before by one of the greatest authorities in matters of art—that is, Dr. Waagen, the director of the Royal Gallery at Berlin. He was examined, in 1835, before a committee of the House of Commons on the improvement of arts and manufactures, and he said that "in former times artists were more workmen, and the

workmen were more artists, as in the time of Raffaelle; and it is very desirable to restore this happy connection." I was glad to find this corroboration of what I intended to say. He says again, "We have, then, to endeavor a connection between these two, the productive and beautiful art." Now, I ask what class of art was it which was in combination with productive art, to make it the parent of such a beautiful offspring in every department? *It was not low art;* it was not the mere knowing how to sketch an object from nature; it was not merely linear drawing; it was not merely elementary art: *but it was high art, and the highest art.* In every one of these cases the state of society was such—from what causes I do not undertake here to say—that it did permit the highest artists devoting themselves to what now they contemn and would despise; and, on the other hand, there was such honor given to the product of industry, that, when it really had the stamp of beauty upon it, it rose of itself to the department of high art.

Let me illustrate what I consider the danger to be guarded against by another example. When you go into a picture gallery now, and you see the portrait of a man, why do you care the least *who* that man was? You see the splendid effect; the countenance, which perhaps has not a beautiful feature in it, but which, by the noble expression, by the beautiful tone of color, by the majestic character thrown around the head, by the harmony between the parts, even by the accessories, is made so glorious that you can gaze upon it for hours. It may be a doge, it may be a merchant, a soldier, or a prince; you care not: you see there, not the portrait, but you see the painting by Titian, or by Rembrandt, or Vandyke; and the artistic merit so completely swallows up all the idea of personality of him who is represented, that, unless it happens to be some one particularly known, you never take the trouble of inquiring whom the painter represents. And why so? Because then portrait-painting had not become a distinct department of art. There was no such thing then as a person who called himself a portrait-painter, who thought he could produce a noble likeness of a man by merely giving a fac-simile of his features; but portraits were paintings by men who who could have painted an historical painting of the highest character, and to whom it would have been thought not unbecoming to commit the greatest artistic works imaginable. But in modern times the portrait-painter is an entirely different person, and the pictures produced by that class of artists are unfortunately of but little value except to those who have a personal interest in the subject of the portrait. You know, too, that every one of these portraits, which cover such a vast extent of the wall of the exhibition, will be transferred to the place of honor over the chimney-piece in the house of the owner; and, when his son grows up, it will be put on one side, that a portrait of the inheritor may take its place: and in the next generation it will be transferred to some other more out-of-the-way corner of the house, until at last it will find a more ignominious position than Cæsar's dust, stopping up a bunghole to keep

out the inclemency of the weather. From what does this come? *Simply from the attempt to divide art into parts*—to say that there shall be a class of men who can do a portrait, but who cannot do a historical or other great painting. And you find a difference when some of the great artists of the present day—for there are some truly great artists in England—do put their hands to what is considered another department of art, and paint the portrait of a friend, or of any one else; it becomes in itself a fine creation of art, and it will not perish when the person is forgotten; but it will be known by the name of the person who painted it, and not by the name of the person who sat for it. In this way, too, high art, when applied to a lower branch, *raises its character.* This is what ought to be the fundamental basis of artistic education. If we really mean to make more than improved designers or draughtsmen for mechanical work, we must have *great artists who are not afraid to work mechanically at the same time that they are great artists;* we must have the feeling that art commits no unworthy condescension in giving immediate assistance to the processes of production. The famous artists of whom I have been speaking were, as we have seen, men who worked at their business, and yet were not considered as working men; they were considered as artists, and treated as such. And it is that, I am afraid, which makes the great difference between our time and theirs. Art, unfortunately, is not now considered so noble as to give rank and station, as it did in those days. I do not mean that the great artists, those who devote themselves to what are considered works of high art, do not receive patronage and countenance, and even high honor; but we find that in those days such distinctions were bestowed on the artists themselves in productive toil. There is not, perhaps, any part of the history of art more interesting and beautiful than those portions of Cellini's memoirs which show us the manner in which he was treated; he used to go, when he pleased, to the pope to take him drawings and models; he speaks of going in without even waiting to be announced—going in the evening, after laboring all day in his workshop, as a matter of course. He was treated in the same manner by the grand duke of Tuscany, and by the king, Francis the First; when he was working for him, the king used to go at any hour and visit him; and Cellini gives rather a characteristic anecdote, proving how very familiar such visits were. One day, while at work, and, as usual, rather in ill temper, an apprentice or servant did something which displeased Cellini, and he roughly took the youth by the shoulders and pushed him across the room. The apprentice fell against the door, which was just then opened by the king, and he fell fairly into the king's arms. Such was the familiar way in which kings and great personages used to visit Cellini, and find him in his apron among his workmen. But I believe, myself, that it is not *patronage* which art wants in modern times. Patronage it has; you, gentlemen, here, many of you, I know, would not scruple to go far beyond the mere calculation of interest, were it in our power to raise, by your patronage,

any one who gave evidence of genius, and reward him as he deserved. It is not patronage, but honor, that art wants.

Now, speaking of the department to which I have just alluded, there is a passage worth quoting from Mr. Ward's book, "The World and its Workshop," on the difference between English and French designers in the textile fabrics. "France has studiously cultivated the art of design, and advanced its professors to the rank of gentlemen; in England, on the contrary, with some exception, it has been degraded to a mechanical employment, and remunerated at weekly wages. France has, in consequence, a species of industry to which we have no claim—the production of design for exportation." Now, having drawn these general conclusions, we must come to some practical applications. The first, that we must avoid making too great a separation between that character of art which it is proposed, now, to impart to our products and the higher departments of arts. I have observed that the separation of art into two departments, high and low, seems to be dangerous, and it will, perhaps, prove fatal. You may educate a great number of good designers, persons who will make tolerable drawings, and with rapidity; but the influence upon these which are considered the lower stages of art must come, not from below, but from above; it is only art in its highest department that gives the true feeling of proportion, the right sense of harmony, whether in color or in design, that gives also that sense and feeling of the adaption and propriety of things to their purpose, which is indispensable. Any one must be surprised at seeing the extraordinary combination of the styles of different countries and times in our works of art, from the want of a regular artistic education. I therefore think that the first thing which must be done is to try an education which will not give merely a great degree of elementary artistic power, but that, while we give what may be called the rudiments of art to every one, if possible, so as to give them all the opportunity of developing a higher taste and power, if they possess it, we must not, in looking beyond that, satisfy ourselves with the idea that we can educate a great number of artisans to a middling degree of artistic feeling, in the hope that thereby we may influence the character of our manufactures; but we must endeavor to combine the two, to bring down the high art to mingle with the lower, in the feeling that it is the common interest and duty of artists to improve the productive arts, *and to carry into actual work—not merely into design*—the powers which they possess.

The evidence of Mr. Skene, before the committee of the House of Commons, is to the same effect. He and Mr. Potter, and every other writer I have seen, agreed that we are not equal with the French in the more delicate operations of art applied to manufactures, and especially in textile fabrics; and he gives this reason: "The system of France is very different from that of this country, because in France artists of the first eminence employ their time—and make it a most profitable part

of their employment—in pattern-drawing, and they are paid very high prices by the manufacturers." This, then, accounts for everything, because it is the union of high art in design with manufacture that makes the French superior. The evidence of M. Coquerel, who is himself an eminent architect and designer, shows that a distinguished artist, who became president of the French Academy of Arts at Rome, and one of the first of his day, was employed at Sevres, in the china manufacture; and he states, also, that of fourteen or fifteen French artists of the first rank, educated at Rome, with whom he was acquainted, many were scattered through France assisting in the different manufactures. Finding the market for the highest class of artistic works so limited, and so full, these men, instead of sinking into despair or committing suicide, as has been seen in similar cases, turned their high talent to the assistance and improvement of manufactures; and they are not thought to have dishonored themselves by doing this; nor is it considered their superior education was thrown away upon them in qualifying them for the posts they now occupy. Why should it not be so here? Let any one go into the exhibition of paintings in London, and look around the walls; he will, perhaps, find only a small number of artists who can, with any hope of advancing themselves in the path to eminence, continue in what they may consider the highest department of art; and I cannot but think there are many in distress, persons who might be making an honorable livelihood, if they would apply their talents to what they would wrongly consider, perhaps, a degrading employment, but which is most honorable—the improvement of art in its productive department.

The second step which seems to me of the greatest importance, is to familiarize the people with art. This I know is a very trite topic, and one which can hardly be considered to require from us much attention. I know it is proposed to make museums in every part, and I think that excellent. But we must observe how it is that that familiarity with art has been obtained by other people; it has been, not so much by having places to which people were to go to see art, but by rendering it familiar everywhere to their eyes. The ancient Greeks, proceeding from other considerations, which we, as Christians, could not for a moment wish to have considered, such as the public spectacles, and feasts, and ceremonies of Greece, filled their whole country with works of art. Any one that will read the works of Pausanias, or the first book alone, will see how impossible it was for an Athenian to go ten yards in any direction in the city without seeing some beautiful work of art. On every side there were monuments, and statues, and temples, of the most beautiful workmanship and design; and the people became impregnated with the sense of artistic beauty; and therefore *whoever, even a mechanic, put his hand to any work, worked under the influence of that feeling.* In a later period, in Rome, there was the same plan of filling the public buildings, the streets and squares of the city, with sculptured monuments and with paintings

hung up so that the people could gaze on them; and Pliny gives us a long list of paintings put up by different emperors; and, by way of showing what was thought by the Romans of our northern ancestors, he says, that among those paintings on the walls of the Forum there was one of a shepherd; and when a German ambassador came to Rome, he was asked at what price would *he* value that picture?—which shows that it was considered by the Romans to be worth a high price, quite beyond a German's estimate; he, having so little idea of art that he did not consider that question applicable to any possible artistic merit, said, "Why, I would not have the man, if he were alive and breathing, if you would give him to me,"—he considering it was the value of the man, as a servant, and not of the picture, that he was to regard. In a later age, at Florence, Vasari tells us how he and Michael Angelo, and other artists, used to meet together, and then go from church to church to see the beautiful works of art in each, and then to discuss and criticise them. In the middle ages it was the *Church*, no doubt, which gave to public admiration the specimens of fine art, and kept them before the minds of all, and, in fact, made the people be artists. The consequence of this was, that, as Cellini tells us, when his statue of Perseus, after having been finished, was put into a public place, and when he uncovered it for the first time, "It so pleased God, that, as soon as ever my work was beheld by the populace, they set up so loud a shout of applause, that I began to be comforted for the mortifications I had undergone; and there were sonnets in my praise every day fastened up on the gate, and the very day I finished my work twenty more sonnets were set up, with the greatest praises of the work, and Latin and Greek poems were published on the occasion." So well had the Italian public learned how to appreciate a noble work of art!

Now, I look forward with no small expectation to what will be done by the new exhibition which is preparing, (this refers to the Manchester exhibition,) because I know that great pains have been taken to collect casts and copies of whatever is most beautiful in every department of art, beginning with the most remote period, down to the present time; and if it be really open to the public, and if, especially, it be open for some portion, at least, *of that day on which alone the artisan can enjoy it*, then I am sure it will do more toward raising the feeling of the people for art, and consequently toward introducing an improved practice, than any set of lessons or any teaching could do. A very strong remark is made by Dr. Waagen, before that committee, when asked if they shut up the museum at Berlin as they do in England, at certain times, to enable artists to copy; he says, "By no means, because I believe art is far more promoted by the people seeing it than it is by any number of artists making copies." But it appears to me *there has been a deficiency in the general education among us in the matter of artistic culture.* I cannot but be struck with this when I see that among all the colleges and schools belonging to this country, so respectable and richly endowed,

there is not one of them, so far as I know, which has made any collection or museum that might train the young men who are educated there in a familiarity with art. I do not think any college in either of our universities, Eton, or any of the schools, keeps before the eyes of its young men examples of painting, sculpture, and of other arts of design, which might accustom them during their early years to admire and appreciate art, and thus to contribute afterward their influence to elevate its character. At the same time, I must observe with sincere pleasure that this is not the case with our Catholic colleges; that, poor and unendowed as they are, there is not one of them which has not striven, at the same time while it has provided itself with a library, far beyond the proportion of its means, if compared with what others have done, to provide also some works of art, and keep them constantly before the students. At Stonyhurst there are many beautiful things, carving, lapidary, silver-work, and jewelry, especially for church purposes. Ushaw, or St. Cuthbert's College, near Durham, is another instance; the walls there are covered with paintings, many of excellent masters, and engravings of great beauty; there is a museum filled with specimens of art; the sacristy of the chapel is growing with proofs of the encouragement given there to modern artists, as well as with carefully-collected specimens of ancient art.

I may be allowed to revert also to the days which I spent in St. Mary's College, at Oscott. There, through the munificence of a departed nobleman, and under the guidance of the refined taste of the greatest artist of this day, because a practical disciple of all the arts—Mr. Pugin—there was collected a museum which would have been worthy of a larger establishment; beautiful specimens of carving, of enameling, and metal-work of every sort, so valuable that persons were sent from the department of practical art on purpose to make molds and copies of the specimens; and almost all the cloisters were covered with paintings, some by very respectable artists, and others good copies. The students were thus brought up in familiarity with choice objects of art, which has had an influence upon their lives since, and induced them to patronize and encourage art. That collection, moreover, was, in the most liberal way, thrown open to every one who chose to come and visit us; we never saw any feeling of narrow partisanship or exclusiveness of religious distinction; the house used to be visited every day by parties of people from the neighborhood; and nothing gave me greater pleasure than to see the young men who used to come there, and who were permitted to walk freely through the house. There was, at no great distance, a very considerable establishment for education, richly endowed, and having everything that could encourage the study of literature; but it did not possess, as it appeared, a single object of artistic interest within its walls; and often did the students of that establishment come up to St. Mary's and roam freely through it, and receive every courtesy. And *that* was at a time when Oscott was considered almost the center of a strong proselytizing tendency, and I know that personally *I* was much more engaged in contro-

versy then than I am at the present moment; and it was pleasing, therefore, to see that there was no feeling on the subject which could make it be apprehended as unpleasant for those young men to come to us. Bodies of those young men used to come to St. Mary's with letters from their principal, couched in the most courteous terms, asking, as a favor, that his students might be allowed to attend the establishment, which could have very little other merit to many than as it was filled with works of art; and on one occasion he informed me that, when any of the students of his house were particularly well-conducted, and had especially distinguished themselves, the best reward he could give them was to send them with a letter to us, to come and see Oscott College. Now, it will give you all pleasure to know that this generous, liberal, and gentlemanly-minded individual, the head of that neighboring college, was—the Rev. Prince Lee.

One thing more, I will observe, is important—that *we must not narrow the sphere of art. There is a tendency to do so in this practical scheme of education.* I observed in the late report, which may be considered as a programme of the department of practical art, that there are prizes proposed for artistic designs in three different departments—for printed garments, fabrics for carpets, and for paper-hangings. Now, one of the conditions of the four drawings to be sent in to compete for the prize in all three instances is this: "the designs to be flat, not imitative, but conventional, without relief, shadow, or perspective." Now, that is the mediæval principle, and cannot apply to other styles of art; *and you are narrowing the sphere of art if you dictate, as a necessary rule* of all designs in those three departments of productive art, that there shall not be relief or perspective in the painting; that the flowers must all be of one color, and that there must be no shadow, and no attempt to copy nature, but that the forms must be all "conventional," that is, such as a rose spread out into four parts, with a point between them, and the lily changed into a *fleur-de-lis*, and no natural forms to be truly imitated. Now, it is folly to think of competing with French art if our artisans are to be educated on that principle, because the beauty of design where nature is copied—where the flower glows in its own colors—will carry the taste of the public, and I think rightly, in preference to a series of flat and unshaped designs. I think it is a wrong principle; and why? Artists will tell you that the carpet is nothing more than a background for the furniture; that the hanging of a wall, paper or whatever it may be, is nothing but a background for the furniture; and therefore that these must be quiet and of a lower tint, with nothing brilliant, and no attempt at the representation of natural objects. *Now, I deny this principle;* they are not background. The papering of the wall is in the place of the ancient painting on the wall; and I do not see why, if you only avoid whatever may offend the eye—such as false perspective—there should not be all the beauty and glow of natural objects given to the pictured papering of the wall. If we are to collect museums, to put before our young artists specimens from the paintings of Pompeii, and

then to tell them that these wall paintings are done on a false principle, because they are good representations of natural objects, and not merely conventional drawings, how are we consistent? And if you tell a young man who designs patterns for carpets that there must be nothing there which would not be, naturally, in such a position—that there must be no sky or flowers there—then you go to make it a mere pavement and nothing better. I should say that the real carpet should take the place of the ancient mosaic. The ancients thought it not amiss to represent whole scenes on their pavement, with sky and rivers, men and horses; and Pliny tells us there were many celebrated men for this sort of work in Greece; but the most celebrated of all was Sosias; and he says among his other works at Pergamus there was a remarkable one which was called "The Unswept House." It was a representation which certainly does not give us a very good idea of cleanliness of domestic habits—of a floor on which all sorts of refuse had been left to lie about, fragments of meat, and the shells of crawfish, and everything which untidy people might leave after their meals. Such were the notions the ancients had of designs. I should, therefore, be inclined to fear that *if we began to deal with art upon a too confined basis*, and on principles which belong only to one period of the history of art, and if we now insist on their being made the sole basis of artistic education, *we shall produce cramped and narrow-minded artists*, and never enable them to take advantage of the great classical patterns to improve their taste.

In concluding, I think among the *greatest errors* that language has imposed upon us, there is none more remarkable than the sort of antagonism which is established in common language as between nature and art. We speak of art as being, in a certain manner, the rival of nature and opposed to it; we contrast them—we speak of the superiority of nature, and depreciate art as compared with it. On the other hand, *what is art but the effort that is made by human skill to seize upon the transitory features of nature, to give them the stamp of perpetuity?* If we study nature, we see that in her general laws she is unchangeable; the year goes on in its course, and day after day pass magnificently through the same revolutions. But there is not one single moment in which either nature, or anything that belongs to her, is stationary. The earth, the planets, and the sun and moon, are not for any instant in exactly the same relation mutually as they were in another instant. The face of nature is constantly changing; *and what is it that preserves that for us but art, which is not the rival, but the child, as well as the handmaid, of nature?* You find, when you watch the setting sun, how beautiful and how bright for an instant! then how it fades away! the sky and sea are covered with darkness, and the departed light is reflected, as it had been just now upon the water, still upon your mind. In that one evanescent moment a Claude or a Stanfield dips his pencil in the glowing sky, and transfers its hue to his canvas; and ages after, by the lamp of night, or in the brightness of the morning, we can contemplate that evening scene of nature, and again renew in ourselves all the emotions

which the reality could impart. And so it is with every other object. Each of us is, but for the present moment, the same as he is in this instant of his personal existence through which he is now passing. He is the child, the boy, the man, the aged one bending feebly over the last few steps of his career. You wish to possess him as he is now, in his youthful vigor, or in the maturity of his wisdom, and a Rembrandt, or a Titian, or a Herbert seizes that moment of grace, or of beauty, or of sage experience; and he stamps indelibly that loved image on his canvas; and for generations it is gazed on with admiration and with love. *We must not pretend a fight against nature, and say that we will make art different from what she is.* I will read you some beautiful lines, which show how our art must be derived from nature. I translate them from the excellent poem of Schiller, addressed to artists:

> The choicest blossom which the parterre warms,
>   In one rich posy skillfully combined—
> *Such*, infant Art crept first from Nature's arms:
>   Then are the posies in one wreath entwined.
> A second Art, in manlier bearing, stands,
> Fair work of man, created in his hands.

I believe the idea of these beautiful lines is taken from the anecdote which Pliny has preserved to us of the contest of art between Pausias the painter and Glycera the flower-girl; she used to combine her flowers with such exquisite beauty that they excited the admiration of the chief of artists, and he did not think it beneath his art to copy on the canvas the operation of her naturally-instructed fingers; and then she, in her turn, again would rival the picture, and produce a more beautiful bouquet still; and the painter, with his pencil, would again rival her, and produce by his art the same effect as she had done with the flowers of nature. *Let us therefore look on art but as the highest image that can be made of nature.* Consequently, while religion is the greatest and noblest mode in which we acknowledge the magnificent and all-wise majesty of God; and what he has done both for the spiritual and the physical existence of man, *let us look upon art as but the most graceful and natural tribute of homage we can pay to Him for the beauties which he has so lavishly scattered over creation.* Art, then, is to my mind, and I trust to you all, a sacred and a reverend thing, and one which must be treated with all nobleness of feeling and with all dignity of aim. We must not depress it; the education of our art must always be tending higher and higher; we must fear the possibility of our creating a mere lower class of artists which would degrade the higher departments, instead of endeavoring to blend and harmonize every department, so that *there shall cease to exist in the minds of men the distinction between high and low art.* I will conclude with another beautiful sentiment from the same poem:

> The bee may teach thee an industrious care;
> The worm, in skill, thy master thou must own;
> With higher spirits, *wisdom* thou dost share,
> But *Art*, O man! hast *thou* alone.

THE DIAMOND AND OTHER PRECIOUS STONES.

By M. Babinet, of the Institute of France.

Translated for the Smithsonian Institution

BY JOHN STEARNS, M. D.

The diamond, called by the Greeks "adamas," from its hardness and infrangibility, has attracted the attention of amateurs of precious stones from the most remote antiquity.

In regard to hardness, says Lucretius, diamonds are placed in the first rank, as they resist the blow of a hammer.

"Adamantina saxa
Prima acie constant, ictus contemnere sueta."

The second of these peculiarities is much more easily contested than the first; for notwithstanding all the fabulous assertions of ancient authors, the diamond, which scratches all other bodies and can be scratched by none, is easily broken by percussion, and is susceptible of *cleavage*, that is to say, of being readily divided by pressing steadily the sharp blade of a steel instrument in the direction of the natural seams of the stone.

When the rude Helvetians captured the treasures which were found in the tent of Charles the Bold, more sumptuous than those of the King, they divided with their hatchets some of the diamonds of this prince, to the great detriment of their value, as the entire stones were worth much more than the pieces into which they were divided. If we examine the many compilations from the ancients made at the time of the renaissance, we shall find a mass of undigested learning on the subject of gems. Notwithstanding the uncertainty of the names which he applies to many of the precious stones, Pliny is still highly esteemed as a compiler from ancient works now lost, and as an author of the first class. It was he who dared to undertake the composition of a history of nature analogous to what had been done before his time in regard to nations. The term *natural history* has become so familiar to us that the idea it conveyed, namely, a history of all things that contribute to make up a world, minerals, vegetables, and animals, has almost entirely lost the original magnitude of its signification. And in this connection it is worth while to pause for a moment to remark that science in its progress, as it has become more real and important, has gradually become more and more modest. Where, as with the Greeks, the word nature, *physis*, signified the generation or origin of beings, with us it is restricted to the system

of objects that constitute the physical universe, and is not applied to the occult cause by which they were produced. Here, as everywhere else, science, in order to make real progress, has abandoned ambitious metaphysical speculations for sagacious observations and wild hypotheses for sober facts.

It would be interesting to trace the history of gems in connection with the history of man from the times of Aaron's ephod to those of the pastoral cross of the archbishop of Paris; from the time of the presenting of rubies, sapphires, emeralds, diamonds, topazes, sardonyxes, amethysts, the carbuncle and loadstone, as offerings in the temple of Jupiter and other pagan divinities, to that of an accumulation of wealth of a similar character prior to the sixteenth century in the treasury of Christian churches.

But, without attempting this labor, we may observe, in passing, that these precious gifts, the offerings of the piety of the faithful, have not always been faithfully preserved. When, during the reformation of Calvin and Luther in Germany, and later, in the time of the French revolution, this votive wealth was delivered over to the civil authorities, it was discovered that many fraudulent substitutions had been made, and that paste had very often been substituted for the primitive gem.

The famous London Exposition of 1851 prided itself upon the possession of the great diamond, the Koh-i-noor, (Mountain of Light,) captured from the Maha-radjas of India, and presented to Queen Victoria. As to the antiquity of this gem, it is asserted that it was worn by Karna, King of Anga, three thousand and one years before our era. Observe the preciseness of this date. I have nothing to offer in objection to it, and am even ready to grant the truth of the assertion; for who can prove the contrary? We can say, however, quite as much in behalf of the truth of the marvelous properties ascribed to precious stones by antiquity and the middle ages, and admit without hesitation, as they have done, the influence of the planets and other celestial bodies. For the cure of all diseases of a moral or nervous character, wherein the imagination exercised a predominant influence, gems were the sovereign remedy. In declaring to a patient that an emerald, placed at the head of his bed, would cure hypochondria, drive away nightmare, calm palpitations of the heart, enliven the imagination, or dissipate mental troubles, success was assured by the faith alone in the efficacy of the remedy. The expectancy of cure in these affections was itself the cause of the cure, and in all of the countless cases in which the moral exercised an influence over the physical, an imaginary cause must produce a real effect. In short, a constant tendency to self-deception of the human mind, which leads us to regard only accidental successes, and to take no note of failures, contributed to maintain the belief in the hidden virtues of precious stones. It is not above half a century since diamonds and other gems were borrowed from rich families to be applied in the cure of local diseases. Care, however, was taken when the jewel was intro-

duced into the mouth, for toothache or sore-throat, to secure it by a string, to prevent its being swallowed by the patient.

The study of precious stones, which may seem frivolous when these are considered only as objects of ornament, rises in importance when looked upon in connection with commerce, optics, and mineralogy. The classic Haüy, creator of crystallographic mineralogy, has not disdained to publish a book on precious stones, in which he leaves nothing to be desired in the way of description. In his preface he acknowledges his obligations to M. Achard, mineralogist and lapidary, of Paris; and I ought to say as much for M. Achard, the son, without whose aid I should not have felt able to compose this article.

What is the diamond? It is the most rare and the most priceless of minerals. What is carbon? It is one of the most common of known substances, found in the earth in immense quantities and furnished by all plants and trees in great abundance. The diamond is priceless, since one of pure quality, of the weight of a twenty-five-franc piece—that is, of 125 carats—will have a money value of at least four millions of francs. Now, the value of an equal weight of carbon is scarcely anything, and yet the two are identical; the diamond is only carbon crystallized. Every one knows that if a body is dissolved in a liquid—for example, common salt, saltpeter, sugar, or alum, in water—the deposit left by evaporation of the liquid will present regular geometrical forms. Salt assumes a form identical with that of playing-dice, to which the Greeks gave the name of cubes; saltpeter presents elongated bodies with four flat sides and square ends; sugar takes the form known as rock-candy; and finally alum crystallizes into pointed pyramids. This latter form is precisely the same as that under which nature presents us with the crystals of carbon called diamonds.

As soon as the character of the diamond was discovered, chemistry aspired to emulate nature in producing the gem from carbon; but up to this time science has been baffled in her attempts—nature has not been induced to reveal the secret of her process. These geometrical products of nature, when not worn by attrition, are as smooth and as polished as the finest cut glass. Colored crystals are also produced by nature as well as white ones. The red ruby, the blue sapphire, the green emerald, the yellow topaz, the violet amethyst, and the crimson garnet are all the products of her unrivalled laboratory.

Chemistry, it is true, furnishes us with hundreds of crystals of different forms, according to the character of the substances of which they are composed, and many of them are not found in mineralogy. Nature, however, as if by way of revenge, has produced in the course of ages, and under the influence of actions scarcely as yet recognized, crystals which art, directed by science, has not been able to imitate. Such is emphatically the diamond, and many other minerals not embraced among gems. To the study of these geometrical forms, whether the products of nature or of art, the celebrated Haüy, about the beginning of this

century, gave many years of his life, and out of this study created a new science, one of the titles to glory of the human mind.

Pythagoras and Plato had without doubt given attention to crystallography, since in their schools they announced the marvelous proposition that nature, in the depths of her recesses, occupies herself with geometrical problems, and that God *geometrizes incessantly*,

Αει δεος γεωμετρει.

The old alchemists contended that the philosopher's stone could be produced from the commonest substance possible, and nature seems to have favored this idea in producing the most costly gems from the most worthless materials. She converts, as we have seen, a small quantity of black and friable carbon into a transparent diamond of a hardness and brilliancy unequaled. She takes a little of the glazing which the potter uses in his ordinary operations, and, coloring it with a trace of iron, produces a ruby or a sapphire. From a little worthless pebble, with slight additions, she forms the topaz, the emerald, and the amethyst. Some of the last-named gems have been reproduced in the furnaces of Sèvres in the same manner, without doubt, as nature has elaborated them, in her vast volcanic workshops, by those mysterious operations which have given to Vesuvius the title of the great crystal manufactory. Every one knows of the sarcasm with which Rousseau reproached the chemist Rouelle, demanding of him that he should produce corn from the chemical materials of which it was composed, rather than destroy that already made in its analysis. What would he say if he had seen the chemist produce carbon from the diamond, as readily as from a bit of wood or sugar, while he was powerless from the carbon to create the precious gem?

It might seem at first sight that those countries containing diamond mines, or mines of crystallized carbon, were the most favored; but this is far from being the case. The mines of Golconda, and of Visapour in India, of Brazil, of the Ural, and of Borneo, are not worth a moiety of those deposits of coal with which nature, a little parsimonious in regard to France, and still more so toward the vast territory of Russia, has endowed Belgium, England, and to an immense extent the United States.

By way of illustration, we can state that England, with all her wealth, does not import precious stones of a value greater than twelve or thirteen millions of francs, while her mines of coal yield a value of five hundred millions of francs per annum. How precious is this coal!

The diamond is commonly found imbedded in a sort of reddish cement. Sometimes the rock containing them requires to be broken, and often the sand at the base of torrents, or the earth which has received the waste of diamond-bearing rocks, is gathered, and submitted to frequent washings by machinery, to exclude the gravel and stones prior to the hand-washing which secures the gem.

Diamonds are always found covered by a rough coat, which is, in fact, the product of the chemical action of the crystalline formation. Nearly

all the other crystals, and especially those of quartz, are much more brilliant in their natural state. Had Socrates, who regarded the natural man as a block of marble, from which art can create a beautiful statue, known of the transformation created by the cutting of the rough diamond, he would certainly have preferred this comparison. The difference, however, in money value between the cut and the uncut diamond is not so great as might be supposed. For if the rough diamond loses half its weight by cutting, on the other hand, its value is doubled by the operation, without estimating the dust remaining, which has a value in the arts from its being employed in polishing many gems as well as the diamond itself.

The ancients do not appear to have had a suspicion that the diamond could be cut. They only knew it in its natural condition as a stone, having eight triangular surfaces, and in every direction presenting a double pyramid.

Louis de Berquen, an artist of Bruges, about the middle of the fifteenth century, conceived the idea of cutting it at first by rubbing two diamonds, one against the other. If, in fact, we cement two diamonds on wooden handles, and rub point against point, we shall, little by little, grind them away, and obtain an artificial unpolished surface. To polish this surface we must use a circular plate of steel or of cast iron, like a grindstone, placed horizontally. But it is easy to see that if a diamond is merely placed against this grindstone, it would require a century to produce a polished surface. All that can be obtained by this process are grooves cut in the iron or steel. To effect the desired object, a happy thought suggested itself to Berquen to sprinkle the surface, against which the diamond was rubbed, with diamond dust mixed with oil. The surface obtained in this way is regular, smooth, and perfectly polished. After the discovery that facets could be produced in the diamond, experience indicated in each case how a particular stone should be cut to produce the most advantageous effect.

There are two principal styles of cutting. The first is called the *brilliant*. In order to produce this style, the diamond to be cut must be pointed. If not naturally in this form, it must be reduced to it artificially. The points on the upper surface are ground down a little more than one-half, and those on the lower or under surface one-eighth. Then the light, entering through the larger upper surfaces, strikes the bottom surfaces, is reflected backward, traverses the side facets, is refracted, and produces prismatic effects. Every one knows what is the result when white light is decomposed into the colors of the rainbow, and coming to the eye, with every variety of hue, produces what is called the luster of the diamond. For this effect the light should not be voluminous, for there might be neutralization of these colors, and white light be reproduced. Nor should the facets be too large, for then the eye would receive all these colors at once, which would also reproduce white light.

The large diamonds, the Regent, belonging to the crown of France,

and the Koh-i-noor, belonging to that of England, are cut with facets too large, and not sufficiently numerous. It would have been better if the large upper surface, called the *table*, had been cut in a series of smaller facets, made to slope toward the edge, as is done for small colored stones.

The following is my method of studying the effect of a diamond: I pierce a hole in a white card a little larger than the diamond to be examined. Then passing a ray of sunlight or that of the electric lamp through this hole, I place the stone in the path of this ray, at a certain distance from the hole, behind the card, so that it shall receive the light on the table of its anterior surface. The rays reflected from the table, and also those which pass through into the diamond, are reflected back on the card, where they exhibit a white image of the table, surrounded by small bands iridescent with all the prismatic colors. Now, if the colors are considerable in number, well separated, and equally spread around the white reflection of the table, the diamond has been well cut. Each of the bands indicates one of the lusters of the stone, which may therefore be counted, and, consequently, in this way, the number, the quality, and the symmetry of the lusters can be determined; errors in cutting can be detected; and the form to produce the best effect can be ascertained. I have always intended to undertake by this method the study of the principal diamonds of France, but have always postponed it, being, like Homer, too much pressed with other work.

The second kind of cutting is called, for what reason I know not, the *rose*. It consists in leaving a large, smooth surface underneath, and in covering the upper surface with a great number of small facets, in order to produce on the face, by the reflection from below, lusters and colors similar to those of the brilliant. This cutting is used for stones of a flat form, the weight of which would be too much diminished in reducing them to the form of the brilliant. In this manner the great Indian diamond of England was originally cut, before it was presented to the Queen; in cutting it as a brilliant it has been reduced from 186 to about 103 carats. It is scarcely necessary to say that, by the process I have given, the rose-cutting can be as well verified as that of the brilliant. In both, large facets should be avoided even for the larger diamonds. As to the identity of the diamond known as the "Sancy," the name of one of the captains of Henry the Fourth, there is no agreement among connoisseurs. All the diamonds which pretend to this name weigh from 55 to 70 carats, and are cut in the form of a flattened pear, almost round, a shape called the *pendalogue*, having facets above and below, with a small, flat surface on the top. Several imitation diamonds cut in this style have given admirable effects, and I think that it should have been adopted in the cutting of both the crown diamond of England and the rough diamond, known as the *Star of the South*, presented to the Academy of Sciences by M. Dufrénoy. This kind of cutting, which I venture to call the *Sancy*, merits as much attention as those

known by the name of the *rose* or the *brilliant.* If from a single luminous point, multiplied by facets, we obtain several colored lights, it is evident that from a number of luminous points more splendid effects will be produced. For this reason the light from a number of wax candles or from uncovered jets of gas is more favorable to the brilliancy of the diamond than that from lamps or gas inclosed in globes of ground glass. Therefore those who sell diamonds would do well to remember that if in exhibiting them they substitute for the one or two large lamps frequently employed, candelabra containing a number of wax candles, the character of the gem will apparently at once be changed, and it will resemble in brilliancy that grouping known as the *parterre* or *basket of flowers.*

Whenever I have been invited to see an amateur collection, among which there was one princely diamond, (that is, above 10 carats weight,) I have often given the owner great and unexpected pleasure by lighting on a mantle-piece from eight to sixteen wax candles, thus calling forth, as it were, all the latent splendor of the gem. The reflection in the mantle-mirror doubles the number of candles; and if we turn our back to the mirror while holding the diamond in the hand, about the level of the eye, and vibrating it rapidly, the most beautiful effects are produced. If this secret had been known to Prince Potemkin, who enjoyed like a sybarite the company of his beautiful diamonds, he would have obtained a much higher pleasure from his favorite contemplation. In the splendid apartments of the Tuileries nothing is more easy to remark than the great difference between the brilliancy of these gems in the rooms lighted by wax candles compared with that obtained in those where gas-jets are inclosed in ground-glass globes. Walking, dancing, every movement of the body, however slight it may be, varies very perceptibly the ever changing play of the lights of this transcendently beautiful gem.

It is remarkable that the price of diamonds has remained invariable for several centuries. A perfect diamond, weighing one carat, is worth about 200 francs. Double this weight, and you quadruple the price, which is as the square of the weight, so that one weighing 10 carats would cost $10 \times 10 \times 200$, or 20,000 francs, which would be more than that of a first-class *solitaire.* Though it does not enter into our plan to speak of the arrangement of diamonds, and the best manner of setting them, which is properly the business of the jeweler, we will say that recently, admirable effects have been produced, at a great saving of cost, in substituting for one very large stone a diamond of more moderate dimensions, surrounded by eight brilliants of one carat each. Suppose we have for the middle stone of the necklace a diamond of four carats, worth 3,200 francs, surrounded by eight stones of one carat, worth 1,600 francs. We get for 4,800 francs an effect equal to that of a 10-carat diamond, which would cost from 20,000 to 25,000 francs.

The mines of India, at Golconda, Raolconde, Visapour, held for a long time the monopoly of the diamond market of the world. Of late,

however, Brazil has added its productions, which, having almost always a slight yellowish tint, contrast finely with the diamonds of India. It is from Brazil, at present, that nearly all the diamonds sold in Europe are obtained. These are first sent to Amsterdam to be cut, thence to Paris and London to be set, and thence they find their way through commerce to every part of the world. Borneo also furnishes a few hundred carats of diamonds. Humboldt conjectured that, from their formation, the Ural Mountains ought to produce diamonds, and research has justified his prediction. It does not appear, however, that these deposits have even yet been made productive in the way of regular mining. Algeria, also, has had the reputation of producing diamonds, and we have seen, in the possession of amateurs of mineralogy, specimens said to come from this locality; but whether these came from a real or supposed deposit, they have had no place in commerce, and the same may be said of the Californian and Australian diamonds. In general, the proportion of diamonds in circulation augments with that of the population that can afford to purchase them, which causes their price to remain nearly the same at all times. A panic due to the discovery of some new diamond beds in Brazil, about the year 1845, caused a temporary fall in the price of this gem, but the equilibrium was soon restored, and now, at London as at Paris, a diamond of one carat is worth the old price of 200 francs, more or less.

The number of stones which surpass in weight 100 carats is extremely limited. It is estimated that among 10,000 diamonds only one will be found weighing 10 carats, and consequently this will merit the name of *princely*. Russia, France, Tuscany, and England possess diamonds weighing over 100 carats. By far the chief among these, on account of its beauty, is the Regent, so called because it was to the Prince Regent that England owed its acquisition. All these large diamonds come from India. The Star of the South, of which we have just spoken, and which was shown to the Academy of Sciences January 3, 1856, came from Brazil, and was obtained from one of the new mines, the discovery of which caused the transitory depression of the diamond market. It was found in July, 1853, and weighed 254½ carats. This gem appeared perfectly limpid, and without that tint which has been the reproach of Brazilian diamonds. The cutting of it as a *brilliant* reduced it to half its original weight, which will make it about the same as that of the Regent, which is 136½ carats. To have cut it in the form which I call the *Sancy*, would have left it three-fourths of its original weight, and have given it a much more splendid luster. When I wished to suggest this the diamond had already been sent to Amsterdam. It was exhibited at Paris in the great exposition of 1856. It is estimated to weigh 127 carats. It is one of the five diamonds to which the name of *sovereigns* has been exclusively applied. Everything indicates that the number of these peerless minerals is extremely restricted, since so few have rewarded the arduous labor of searching for them.

If no more should ever be found, it will be on account of their extreme scarceness, which recalls a saying of Tacitus with regard to the pearls of England: "It is rather nature that fails in their production than the avidity of man in their discovery." Hitherto Borneo has contributed no diamond of any considerable size. It is true, however, that the almost impenetrable forests of this equatorial isle have prevented a thorough research. A late number of the Journal of the Geographical Society of London gives about 2,000 carats as the annual product of the mines of Borneo, which have never yet yielded a diamond of 36 carats. The monopoly of the government of Holland in this matter is found to be quite profitless, and it is probable that, as in Brazil, a considerable portion of the production is abstracted by contraband trade.

The rank of a diamond can only be approximately determined by its weight. If, for example, it is not of a beautiful water, perfectly pure, colorless, and limpid, it cannot receive the title of sovereign. Furthermore, if its luster is not brilliant, it will have to be recut to render it perfect, and in this operation it will lose weight. The Regent and the Koh-i-noor are equal in beauty, but the Regent of 136 carats is more valuable than its rival, which has been reduced in cutting from $186\frac{1}{16}$ carats to $102\frac{13}{16}$ carats. The diamond of Tuscany is of an inferior color, a yellowish lemon. The great diamond of Russia is rather ill-shaped; it is like a pigeon-egg cut in half, with facets over its whole contour. It is only a big stone, a species of heavy rose much too thick. If the Koh-i-noor and the Star of the South had been cut in the Sancy form, it is probable that with a brilliance equal to that of the Regent they would have surpassed it in weight. The Star of the South, when I saw it in the possession of M. Dufresnoy at the Institute, weighed $254\frac{1}{2}$ carats; but by injudicious cutting, I regret to say, it was reduced to 127 carats.

Permit me further to remark in regard to the Sancy form that it always admits of a subsequent cutting into that of the brilliant, and is easily experimented upon. For this reason it is prudent not to sacrifice until the last extremity so much weight as must be lost in reducing a stone of the form of the Indian or Brazil diamond by the ordinary cutting. I have seen at Amsterdam a model of the form which the latter would take by ordinary cutting. It will be like the Koh-i-noor, that is to say, not sufficiently thick for the size of its face.

In comparing the English diamond with the model of 100 carats given by Jeffries it will be found that its extent of face is almost double what it ought to be for a diamond properly cut.

It would be a curious speculation to follow the future history of the Star of the South after having shone at the French exposition. What name will this sovereign diamond assume? Will it be Albert or Francis Joseph? The proud Americans, sagacious estimaters of all commercial values, will they have the ambition to possess one of these rare productions of nature? "How have you managed to put so immense a price

on this pearl?" asked Philip II of an eastern merchant. "Sire, I knew there was in the world a King of Spain to buy it."

Thus far we have said little for science in this dissertation, and yet precious stones, and, in general, all crystals, from their geometrical forms, their chemical and mechanical properties, their weight, their color, their action on light, and their electrical qualities, they all offer the most delicate as well as interesting applications of the principles of physics. Haüy conceived a crystal to be made up of an assemblage of minute parts or molecules, each having the same definite form. From a few of these elementary molecules, which he called primary forms, he was enabled to build up all the forms which occur in nature, and in so doing he was led to inquire whether the same elementary forms might not give rise to more than one derivative form, or, in other words, whether the same substance could not crystallize in more than one form. Nature replied that she had anticipated his question by producing a specimen of the anticipated form. By the application of mathematical analysis to the fertile conception of Haüy all the forms of crystals which can possibly be produced by an aggregation of a given elementary form, as well as the forms which are incompatible with a particular elementary molecule, can be foretold, and these predictions are, in all cases, found to be in exact accord with the actual facts of observation; while the chemist and the mineralogist are continually adding to the list of crystals of theoretically possible forms, in no case has one been obtained of an *a priori* incompatible form.

Hardness is an important quality by which valuable stones are distinguished. In the cutting of the Koh-i-noor it was found that it required a whole day to produce facets which could be commonly formed in the course of three hours. It was also found necessary to increase the rapidity of the rotation of the wheel on which the diamond powder is spread. In an experiment made some years ago at the expense of the Institute, a black diamond of Borneo was put in the hands of Gallais, the diamond-cutter. On this he wore out a steel wheel and a large quantity of ordinary diamond powder without making the least impression on its surface. It lost none of its roughness, although loaded with a considerable weight, and heated almost to whiteness by the rubbing of the wheel, which revolved with such velocity as to emit a continual shower of sparks during the operation.

This intractable substance required the powder of black diamonds, like itself, to produce the desired effect, and doubtless some day the powder of black diamonds will be used to advantage in cutting the ordinary diamond as well as in other processes of the arts. Every one has seen a glazier, with a minute point of a diamond, trace upon glass an almost imperceptible groove in the crust of the glass, which renders it easily frangible in a given direction. It is conjectured by some that the ancients in engraving on sapphires and rubies have used a diamond point as a burin, and the finish of some parts of cameos and intaglios deeply

cut would appear to warrant this supposition. An art has been lost to France. Who will restore it? Since the last encouragements given to engraving on stone by the Empress Josephine and Napoleon I, everything of this kind comes to us from Italy, and there is not a single glyptic monument of the reigns which have succeeded the Empire.

The diamond is heavier than rock-crystal and lighter than white sapphire. It has almost the same weight as the white sapphire of Brazil, called *goutte d'eau*. It is often confounded with these three stones, which resemble it in whiteness. Let us see then how these may be distinguished by the weight.

It is known that if a real diamond be suspended by a fine thread from a delicate balance, and when in perfect equilibrium it be immersed in a glass of water placed immediately under it, it loses two-sevenths of its weight, or, in other words, two-sevenths of its weight in air must be added to the pan from which it is suspended to restore the equilibrium when the diamond is in the water. In like manner, a diamond weighing 21 carats loses in water about 6 centigrams. A white sapphire of the same weight loses only a fourth of its weight when weighed in water, that is to say, about 5 centigrams. A piece of rock-crystal in the same conditions loses 8 centigrams. Hence, whenever any species of crystal weighed in water loses more than two-sevenths of its actual weight, it cannot be a diamond. We shall presently see how the diamond is distinguished from the white topaz, which, like itself, loses in water two-sevenths of its weight.

Chemical tests being, in general, very difficult of application, and involving a loss of the substances examined, need not here be described; but we shall point out an optical test of a very delicate character which traces at once the line of demarkation between the diamond and all other colorless gems; we refer to that of double refraction.

In looking through a transparent stone at a detached object, such as the point of a needle, or a small hole pierced in a card, the object is seen double, as if there were two needle-points or two holes. This phenomenon is called double refraction, and is exhibited by all white or colorless gems except the diamond. As some little dexterity is required to readily exhibit this curious property, the object to be looked at and the stone should be fixed at the proper distance apart on a support by a little modeling-wax, so as to be more conveniently seen by those interested in the experiment. M. Haüy was often called upon in consultations of this kind, and sometimes, in the case of a suspected fraudulent sale, he gave his testimony in court as an expert in regard to the character of gems. The white topaz of Brazil produces double refraction, and may at once be recognized by this quality as a false diamond. I have a painful recollection of a visit from an English gentleman, who brought for my examination a magnificent white topaz, which, had it been diamond, would have been of immense value. It was very easy for me, from the cutting of the stone, to perceive the double refraction; but

such was the agitation of the owner, and so convulsively did his hand tremble, that I was obliged to attach the stone to a wooden ruler with a bit of green wax before I could render the phenomenon clear to him. The instant he saw the double refraction, the bearing of which I had explained, he seemed overcome with emotion; and after remaining some minutes in a half-stupefied condition, he suddenly rose and abruptly took his leave, doubtless to hide his emotion, too powerful to be controlled. He afterward sent me his card, apologizing for his hasty departure, but I never learned what great interest I had compromised or what hopes I had dissipated in thus determining the character of the stone. In the work of Mawe, it may be seen that the white sapphire and the white diamond owe their high price to the fact that they are often fraudulently substituted for diamonds. Mawe might have added, also, the white zircon, which is heavier even than the sapphire, and which much more resembles the diamond. To exhibit one of these stones in dress as a real diamond may be only a small exhibition of vanity, but to sell one for a diamond is a felony which, fortunately, is recognized as such by our courts of justice.

I need scarcely add that the zircon, like the white sapphire and topaz, possesses the quality of double refraction in a high degree. The test of double refraction is a very convenient one, because it can be exercised without unsetting the stone, and without any complicated apparatus. A little practice enables any one very soon to learn how to recognize the phenomenon; and this is not much to pay for gaining so absolute a means of identifying a false diamond.

Diamonds are capable of being colored in various ways. A slight tinge, as in the case of the great Tuscany and the Russian diamonds, detracts from the value; but when a diamond is found of a lively and rich color, it is very much sought after as a very rare specimen. The Marquis of Drée possesses several of this kind, and especially one of fine rose tint. The specimens which have this character are called *stones of affection*, and really their owners sometimes regard them with a sentiment which fully justifies the name. Among the crown diamonds of France there was one of triangular shape, of a fine sapphire blue, and weighing 60 carats. This disappeared at the time of the theft of these diamonds, none of which, except the *Regent*, were ever recovered, doubtless because this latter was of more difficult sale than the rest. During his imprisonment, the thief enjoyed among his companions great consideration on account of the magnitude of his villainy. On what may not distinction be based in this world?

But the wonder of all colored diamonds is the blue one, owned by Mr. Hope, the form of which has been engraved in the report of the London Exposition. Mawe characterizes it as *superlatively beautiful*. It weighs $44\frac{1}{4}$ carats, and often, according to Mr. Tennant, unites the blue color of the sapphire with the prismatic luster and brilliance of the diamond. Every one who has studied the play and the effect of precious stones in

any brilliant evening assembly has remarked that the sapphire, sparkling as it may be by day, becomes dull and lusterless in the light of lamps, wax candles, or gas. It would be curious to know whether the same loss of brilliance happens to the blue diamond of Mr. Hope, which I do not hesitate to place beside the sovereigns in value, because, though less heavy than they, it surpasses them in rarity. The term *stone of affection* is scarcely an inappropriate name for this precious object, though it is sometimes applied with more questionable propriety. I once saw a stone at M. Bapst's, known as a *black diamond*, which had the color of a tobacco-leaf, and was only admirable on account of its singularity. Louis XVIII, however, selected it for the crown of France, at 24,000 francs, but it was never placed there. Such diamonds are always cut very thin; for what is the use of thickness in a stone which is not transparent, and of which the superficial brilliance is quite vivid? If to an amateur such a stone should become one *of affection*, he certainly would run no risk of having his taste disputed. It is curious to remark that Pliny says almost the same thing of Nonius, who, owning a beautiful opal, preferred to quit Rome as a proscribed traitor, rather than yield to Antony his *stone of affection.* "It was," says Pliny, "an astonishing instance of tyranny on the part of Antony to proscribe a citizen for the sake of a gem; but we can none the less wonder at the obstinacy of Nonius, who, rather than give up his beloved opal, suffered himself to be exiled from his country. In reading the interminable list of marvelous qualities attributed before the seventeenth century to gems, we may understand something of the extreme value set by the possessors of precious stones on these treasures. The native Indian princes are great amateurs of diamonds, and seek for them with great assiduity. In one of their collections I have seen a small natural diamond, with brilliant points, encased in the red cement which ordinarily envelopes the stone in the mine. This specimen, which was about the size of a small hazelnut, and in which the little diamond was enshrined within the cement, formed an object well adapted to excite the wonder and admiration of the mineralogist, as well as the superstitious regard of the princely, though unscientific, owner.

Mawe states that of all values the least variable is that of the diamond. He cites various crises which have occurred in England in the quantity of diamonds received, and shows that, with regard to price, these crises have been generally very light and of short duration. There have been two great panics in the diamond market since 1840. The first was on the discovery of the new mines in Brazil, about 1843 or 1844. The second was in France, and followed the commercial shock caused by the revolution of 1848. The price of diamonds then rose and fell with other securities, and in precisely the same proportions. The price is now about 200 francs the carat, a price indicated by Jeffries reaching to about 250 francs. M. Castelnau, in his Voyage across South America, hints that the fall in the price of diamonds came from a diminution in the taste of society

for these brilliant and other frivolous decorations. If the depreciation in the value of diamonds is to depend on a decline in the taste for luxury and ostentation, a desire to shine, and even on the cupidity of man, a rich commerce in these gems may be assured in London and Paris for many centuries to come.

Without recurring to the *Arabian Nights*, or to the legends of the middle ages, where gnomes and griffins are seen jealously guarding these treasures of the earth, and only by the force of some cabal allowing mortals to obtain them, it is evident that a great value assigned to a small quantity of mineral substance has given rise to singular changes in fortune. I do not know on what foundation Mawe says that Liégés, embassador to the court of Berlin, obtained from the King of Prussia a treaty of alliance, offensive and defensive, by dazzling his eyes with the splendor of the *Regent*, for the cession of which by France the abbé allowed the King to entertain a hope. Frequently the precious stones of sovereigns have been used as pledges for the payment of debts; but these transactions are comparatively of little interest, and we prefer much more to contemplate the incident of a poor gardener of Golconda finding in his garden a beautiful stone, which proving to be a diamond, afforded, not only ease and comfort to himself and his family, but opened to his whole country a source of riches. We also prefer to dwell on the fortune of a poor negress who found the Star of the South, in July, 1853, while washing the sands of the Brazilian mine of Bagagen. According to the ancients, Hercules presided over the discovery of treasures. By this perhaps they wished to indicate that what is truly valuable can only be attained by untiring industry. But be this as it may, the discovery of a gem was never considered by them as a favor from Hercules, but as the reward of labor.

An anecdote of notable fidelity is connected with the *Sancy*, which is worthy of repetition. This gem was bought at Constantinople during an embassy, by a baron of the name of Sancy, for 600,000 livres. During the many years in which Henry IV, after the death of his predecessor, was rather an appendage to the throne than King in reality, several of his barons rendered him pecuniary assistance, and, among others, the Baron of Sancy, who placed the diamond bearing his name in charge of a domestic, to be delivered to the King. In the brigandism which then desolated France, this servant was attacked and assassinated. For a long time his master knew not what had become of him; but after much searching it was discovered that he had been killed in a certain rural commune, and that his body was interred in the cemetery belonging to the locality. When condolences on this discovery were tendered to the baron on the loss of his splendid jewel, he replied, "You are very much in error, gentlemen; since I now know where to find the body of my servant, I know, also, where to find my diamond." In fact, when the body was disinterred the diamond was found; it had been swallowed by the man to secure it from his assailants.

I may in this connection also recite an incident coming within my personal knowledge. I had intrusted a diamond of considerable value to a young trader to be recut in Amsterdam. He there, however, met with reverses, and returned to Paris in a state of the greatest destitution. During the last days of his homeward travel he was obliged to live upon the wild fruits of the earth, and to sleep in the open air. Although I found him on his return in an apartment with bare walls, and his couch a bed of straw, he had been faithful to his trust. He handed me my jewel, apparently unconscious of merit, merely claiming from me the price of the recutting. After this sad epoch, fortune smiled upon him, and in his prosperity I fancy that I see a providential recompense of such rectitude amid unusual temptation.

The art of making diamonds has been almost as eagerly sought as that of producing gold. The problems are not, however, the same in principle, since to make a diamond is simply to crystallize carbon or charcoal; while in producing gold the alchymists attempted to change the very nature of bodies, and to make gold of all things. Modern chemistry having burnt the diamond, and discovered that the product of its combustion is the same as that obtained by the burning of charcoal, we would suppose that some peculiar compound of charcoal might be found which, submitted to such process as would allow the carbon to separate very slowly in a condition of perfect stillness, would produce regular crystalline forms.

It is thus that sugar, salt, and alum are deposited when the water which held them in solution is evaporated very slowly and in perfect stillness. Looking at it in this light, there is a curious substance which renders the experiment of diamond-making a hopeful matter. It is not generally known that in combining sulphur and carbon a colorless liquid is produced resembling water, and containing really nothing but sulphur and carbon. If by some process the sulphur could be got rid of, either wholly or partially, we might expect to see the carbon deposited in the crystalline state. So far this hope has failed. Many other plans have also failed, so that at this day the crystallization of charcoal is by most persons a thing despaired of. Despretz, a member of the Institute, was however, of a different opinion. By means of the voltaic battery he has obtained on a thread of platina small crystalline depositions, which, by their form and hardness, seem to be really embryonic diamonds. These crystals, or rather, let us say, these particles of diamond dust, have been used in polishing hard stones, in the same manner as ordinary diamond powder. The scientific question is then resolved. But this ingenious and sagacious academician did not stop here. He organized, as we may say, hundreds of preparations to facilitate the precipitation and aid crystallization of charcoal under the influence of electricity, an agent which in the researches of men is the obedient servant of his will. These interesting facts lead us to indulge the hope that persevering and sagacious labor will be rewarded by success in the crystallization of carbon,

and the manufacture of the diamond. Although this result might not be advantageous to commerce, it would be so to science. Nowhere does nature show us the diamond in the locality where it has been formed; it is now only obtained from ground which has changed its place, so that we get no light on the primitive conditions of its crystallization, a circumstance which seems to confirm the views of Despretz, which is, that in Brazil, side by side with the diamond, there occurs a curious substance as hard as the diamond, which is called by the Portuguese *carbonado*, and in trade at Paris *carbone.* Speaking of the mines of Brazil, Tennant says of it: "There is found here a considerable quantity of a black substance of the same specific gravity as the diamond, laminated or rather composed of a succession of laminella generally broken into separate fragments. It is too imperfectly crystallized to be cut; though it possesses in places the brilliance of the diamond, and can be reduced to powder for the polishing of other stones. Its name, *carbonado*, is due to its having an appearance resembling charcoal. May not this be the same substance as that artificially obtained by Despretz? In the age of Louis XIV, it was thought that it was quite possible to increase the size of diamonds by placing them in certain solutions, just as a piece of salt may be increased in size by placing it in a solution of the same substance. Despretz has, doubtless, considered the property that a crystal possesses of attracting and regularly arranging around itself particles of matter analogous to its own. At present this is the whole scientific condition of the subject. Let us wait for future developments.

Several years ago the premature announcement of the artificial production of diamonds agitated all Paris. Baron Thenard, however, by an experimental examination reassured the many merchants and families who had been alarmed on account of the threatened depreciation of their fortunes, based on the value of this queen of gems. Since this time the number of diamonds has increased in France, and is every day increasing, even more rapidly than in England, and now represents an immense capital. According to the remark of Achard, there is no article which being resold, suffers so little loss, so little depreciation, while at the same time it is always in demand. It may almost be considered a circulating medium for high values. Furthermore, in the actual state of physics and chemistry, nothing warrants the fear that the artificial will ever compete with the natural product. The case is analogous to the well-known production of the gold pieces made by M. Sage, from gold extracted from the ashes of certain burned vegetable substances, a beautiful scientific result, but by no means lucrative, since every piece of twenty francs cost 125 francs in the making.

In like manner, we may say that if the process were known, the artificial gem would cost more than its worth.

The other precious stones have been designated "colored gems." In fact, their principal merit is the beauty of color and play of light which distinguishes them, but to this we may add hardness, which insures their

preservation, and which is one of the most important qualities that a precious stone can possess. Pliny says that in gems we see all the majesty of nature united in a small space, and that in no other of her works does she present anything more admirable. According to him, the first one who wore a precious stone was the Titan Prometheus. Released from his bonds and impressed by some ideal sentiment, he inserted in a piece of his chain a fragment of the rock to which he had been fastened, and thus formed a ring, which he ever after wore in memory of his misfortunes. Is there not some allegorical sense in this story of the construction of the first ring? What leads us to this supposition is the mysterious personage himself who is made the wearer. This grand personage Prometheus, the benefactor of man, who gave him fire stolen from the gods, has always been venerated in antiquity for his opposition to the imperious domination of Jupiter.

The ancients included also, under the name of gems, stones engraven either in relief or in intaglio, and in this form of art they have left us the most admirable productions that the imagination can conceive. Here, as in sculpture, the moderns have neither surpassed nor even attained to the perfection of the works of antiquity. Engraven stones, which were used as seals, are now the most precious and valuable of relics, while they afford us definite mineralogical ideas as to the various kinds of ornamental stones known from the earliest period of history.

Stones of color do not probably, at the present day, represent more than one-tenth of the total value of gems, while diamonds may be estimated as ninety per cent. This was different among the ancients. With them the diamond was hardly known as an ornamental jewel, because it was uncut, and did not exhibit those vivid colors which now place it in the highest rank among precious stones. Furthermore, our system of lighting with lamps, gas, or candles, throws upon all objects tints very unfavorable to the natural color of gems. Thus the garnet, turquoise, amethyst, and even the opal, lose much of their luster in these artificial lights. When a colored stone is placed in the path of the solar spectrum, its color will vary with the portion of the spectrum which falls upon it; and two stones of the same color, but of a different nature, will exhibit different effects. Thus a paste, placed beside a fine colored stone, betrays its worthlessness. A simpler method of testing stones is to look at them through a bit of glass colored red, yellow, blue, or green. Every stone will exhibit under this test properties peculiar to itself, and by which its nature may be recognized.

Since we have spoken of paste, I would remark that in spite of the high price of fine stones, there are fewer false ones used than at first we should be inclined to believe. Paste, colored or not, is only a very fine glass overcharged with lead and enamel, analogous to the best quality of cut-glass for table service. In the early times of its substitution for precious stones, it was cut very carefully; now it has become common and cheap and inferior in workmanship. Besides, national

riches augmenting from day to day, and the insufficiency of paste for beauty and duration becoming more and more apparent, a greater expense for something of imperishable value is preferred to a less price paid for what is really an article of no permanent worth. We are now long past the time when the Duchess of Berri, arriving in France, received for her bridal ornaments only paste, and when, in order to make the Duke of Wellington a present in diamonds of less than a million francs in value, the Paris trade was obliged to borrow from the civil list a certain number, guaranteeing their restitution in kind.

Before speaking further of colored stones, a question presents itself: Can science explain the coloring of these gems? There are, I suppose, few persons who do not know that the white light which reaches us from the sun and other heavenly bodies can be decomposed into a number of colored rays. Thus, when the light of the sun passes through a triangular prism, it is bent, and will trace on a white card placed opposite to it an iridescent band, in which Newton has marked seven colors, according to some idea of analogy with the seven notes of a musical octave; an idea which is, after all, without foundation, since every prism gives its own peculiar band. The idea was by no means new. The Greeks and Romans entertained it, and Nero, who in dying pitied the world for losing so great an artist as himself, has sung it in verse. A child blowing a soap-bubble produces colors as splendid. In a word, every thin plate of any transparent substance whatever becomes colored under white light. Striated surfaces also offer effects not less brilliant; so that, to clothe certain insects more vividly, nature has grooved the tissue that envelopes them. The globules of clouds between us and the moon produce also, with white light, the most vivid colors; and, above all in beauty, the *iris* or rainbow, which the sun paints in a thousand colors in the drops of the falling shower, is the transcendent effect of decomposed light. Nature always, with a palette, so to speak, charged only with white, knows the art of spreading over all her pictures the magic and glow of the most brilliant coloring. But we have not exhausted all the resources of this coloring, the secret of which is the light itself. How shall we explain the whiteness of the snow, which covers our planet at either pole, and on the summits of the loftiest mountains? How account for the perpetual greenness of countries covered with plants and trees, the blue of the vast aerial sea which envelopes the earth, or the color of the great ocean which rests on its surface? Here science is in default. The cause of the color proper to bodies is only half perceived; and we can say still that which Huyghens said at the end of the seventeenth century, "In spite of the labors of Newton, no one has yet fully discovered the cause of the color of bodies." We must then admire, without penetrating their secret, the unparalleled red of the oriental ruby, the pure yellow of the topaz, the unmingled greenness of the emerald, the soft blue of the sapphire, and the rich violet of the amethyst. This is not the only thing the discovery of which we shall leave to posterity.

In the enumeration that follows we shall place the precious stones in the order of their actual value. This order varies little in different parts of the world. When an extraordinary demand, however, occurs, that causes a rise in price of any particular gem, there flows into the market such an overplus of that gem, that a fall in value is at once effected. This is the case at present with the beautiful Hungarian opal, which in the last ten years has become abundant, the mines producing it being more actively worked on account of the high price of these stones, which for a while has surpassed that of the sapphire. The oriental *ruby* is, for its price as well as its beauty, the first in rank among colored stones. In order to appreciate its color in its finest quality we must compare it with the blood as it spirts from an artery, or the red ray in the solar spectrum. It is the pure red on the painter's palette, without any admixture on the one side of orange, or on the other of violet. Many of the stained-glass windows in our ancient churches, when traversed by the rays of light, give this color in its brilliance. The ruby is excessively hard, and, after the sapphire, which surpasses it a little in this respect, is the first of stones, always excepting the diamond, to which there is nothing at all comparable. According to a perfectly just remark of M. Charles Achard, more competent than any one in France to give an opinion touching the trade in colored stones, there is a great difference between these and the diamond, which, from the minutest specimens to those of princely or sovereign size, have a fixed price proportioned to their weight, as is the case with gold and silver. As for rubies and other gems, the very small specimens have hardly any value, and it is only when of some weight that they command high prices. Rubies are, therefore, much used for watch-pivots, and, from their abundance, are of little value; but for a ruby of 5 carats, double the price of a diamond of the same weight will be paid. If the ruby weighs 10 carats, triple the value of a diamond of the same weight may be asked for it; which price would be about 20,000 to 25,000 francs. All the world admits that a perfect ruby is the rarest of all the productions of nature. Its tint shows to the same advantage by day as by lamp light; but to render the color more resplendent it should be placed in the midst of the red rays of the spectrum in such a manner that the rest of the colors do not fall very near it. The possessors of choice collections of stones can repeat this interesting experiment with various stones, placing each in that color of the spectrum which is analogous to that of the stone itself. It is a severe test for the purity of the tint; for if pure and unmixed, the stone will appear completely black in every other light but its own. Milky and turbid stones cannot bear this test.

When Pegu was annexed to the British East India Possessions, it was thought that that country, so rich in rubies, would send many of these stones, so jealously guarded by the Indian princes, into the European market. Such has not been the case. It is not yet proven, however, that the ruby mines are still worked; and this part of Asia is the least

known of all the countries of the globe. Merchants in rubies will never cease expatiation on the number of tigers, lions, elephants, and venomous serpents which people the forests and the plains of this country, which, according to them, is only accessible by the openings of the rivers from the sea. The actual state of the island of Borneo, as authentically given, seems very much to confirm these rather interested accounts. I do not know that the rajahs attach a superstitious importance to the possession of rubies, but it is certain that they never sell any of considerable weight. With the *Koh-i-noor*, Runjeet Singh possessed a no less precious ruby, which was of the shape of the large end of an egg that had been cut in two. This enormous gem made a part of the necklace of this prince, and was estimated by him, without any fear of finding a purchaser, at 12,500,000 pounds sterling—about as much as 300,000,000 francs. We know nothing of the quality or weight of this ruby, which has not yet been brought to England. The ruby is, with the sapphire, the zircon, and the garnet, one of the heaviest of stones. In water it loses only about the fourth of its weight.

The Indian princes set their beautiful rubies in the collet of a ring, somewhat elevated, and surround them by several rows of small diamonds, so that the whole produces a kind of disproportionate elevation, contrary to our ideas of good taste, which admits but a single stone in a simple French setting, the stone not too prominent—for example, in diamonds, a solitaire of three or four carats.

The composition of rubies is no less extraordinary than that of the diamond. Like the sapphire, the ruby is nothing more than a bit of crystallized earth, colored by iron, which naturalists call the painter of nature. It is not too much to repeat the strange assertion, that nature has made the most precious stones with the most common materials, we will say that this kind of earth, called *aluminium* or clay, and the white pebble or rock-crystal, called *silica*, or flint, form the base of nearly all gems. Opal is rock-crystal with water. Topaz joins a little fluoric acid to silex and aluminium. The emerald, the crysolite, the aqua-marine, the tourmaline, and the eulase contain another element besides silex and aluminium, viz: *glucine*. Finally, garnet is so ferruginous that it acts on the magnetic needle. The zircon, a stone very little esteemed in France, has for base a peculiar kind of earth called *zircone*.

As accessory to the ruby, we may mention a stone less deeply red in color, called the *spinelle ruby*. The crystalline form of this differs from that of the oriental ruby, which is a six-sided cylinder, cut squarely at both ends; while the spinelle is, like the diamond, a double pyramid. The name of *balass ruby* has been given to a stone of Magal, which several authors regard as a real oriental ruby, only having a less rich color. The ancients did not apply the name ruby to this stone. It is called by Pliny *carbuncule*, (incandescent coal,) and by Ovid and the poets *pyrope*, or that which has the color of fire—

Flammas imitante pyrope.

With us the word carbuncle is little used except to describe a ruby of considerable size. Pliny has evidently confounded the Indian ruby with the garnet, which is found everywhere. Certain rubies cut spherically—a form which is called *calotte spherique*, tallow drop, or *cabochon*—present in the middle of their red tint a white six-rayed star, which changes with the position of the eye and forms in the sunlight a beautiful spectacle. This effect is called *astérie.* It is found also in the sapphire, a near relation of the ruby; like it, being composed of aluminium, and colored by iron, differing only in its color, which is blue, while that of the ruby is the most vivid and purest red.

Next in rank to the ruby we place the *emerald*, of which Pliny says no gem has a color so agreeable. This stone, which comes to us from Peru and New Grenada, is very soft, hardly scratching rock-crystal. It is found in beautiful green crystals, implanted and produced in a kind of freestone of a whitish color; and we can comprehend no cause other than electricity for such a deposit as that of the emerald in the midst of a stone differing both in nature and in color from this gem. Nero, who was near-sighted, used an emerald, hollowed on both sides, through which to look at the games in the amphitheaters. This was doubtless the first approach to spectacles, since this invention does not date very far back.

The emerald, like the ruby, is a six-sided prism and squarely cut at the ends. This stone is very light, losing in water more than one-third of its weight. Its tint is so lovely that we overlook its want of hardness, which might properly almost exclude it from the rank of distinguished gems. At the time of the conquest of Peru a magnificent emerald was sent in homage to the Pope; and several years afterward the emerald mines there were said to be exhausted or lost. About twenty years ago the principal of a large establishment in Paris, M. Mention, received from South America some magnificent specimens, which quite revived the emerald trade, continued since without interruption by Charles Achard. The deeper the hue of the emerald the more it is esteemed. It is the largest end of the crystal that is the most strongly colored. The emerald loses none of its brilliance in artificial light; a valuable property in our modern society, where all great reunions are held at night. Haüy includes in the emerald family the aqua-marine and the beryl, one of a greenish blue, the other yellow, but both being like the emerald in form and chemical composition.

The emerald, as well as all stones whose color we wish to develop, should be cut with a flat upper surface, surrounded by retreating facets, continued all the way underneath. The orientals cut them in broad thin plates, which, apparently, ought to show the colors of the stone to the best advantage; but the reflection of white light from the large upper surface becoming mingled with that which traverses the gem, renders the hues of the latter less discernible. This is the reason why they are not cut with a table and surrounded by facets; for thus in

avoiding a large reflecting upper surface, the stone is made to exhibit its fundamental color throughout its whole extent. The emerald, though much cheaper than the beautiful ruby, is nevertheless much admired and sought for. We might almost call it a "stone of general affection," so much is it esteemed by the many.

The *sapphire*, which comes after the emerald, is the hardest of colored stones. It may be considered as a blue ruby, or the ruby as a red sapphire. With Haüy and Mawe, we can say that aluminium is susceptible of crystallizing in almost all colors. The mineralogical species to which the sapphire belongs is called the *corindon*. After the red *corindon*, or *oriental ruby*, comes the blue *corindon*, or *oriental sapphire*. Sometimes the *corindon* is of a beautiful yellow color; then it is called *oriental topaz*. More rarely it is of a violet hue; then it takes the name of *oriental amethyst*. Finally, it may be perfectly colorless, like rock-crystal, when it greatly resembles the diamond, with which it is sometimes confounded, but by its greater weight and its double refraction it may be easily distinguished.

By the microscope there may be discovered, in certain pale sapphires, traces in the direction of the faces of six-sided prisms. The light reflected by these internal filaments produces three small brilliant traces transversely to the filaments and to the faces of the prism. The crossing of these little bright lines forms within the stone a six-pointed star, which gives to the stone the name of *starry sapphire*. Among the orientals these stones are highly esteemed, especially when they exhibit the star in a ground of deep blue. Corindons of all colors are susceptible of being thus marked. In his voyages in Africa, M. Abbadie wore a blue starry sapphire, which often commanded the respect of the natives. There are stars on a red, blue, or yellow ground, according to the color of the corindon. As yet, this phenomenon has never been seen in the white sapphire. I have just said that this reflection arises from little filaments within the stone. These may result either from some foreign substance or from minute hollows left by the regular disposition of the particles at the moment of crystallization. If, instead of trying to observe these starry appearances by reflection, the stone is cut so that it can be looked through, then the phenomenon can be easily seen. Unless the stone is of a very perfect crystallization, the observer who takes for the point of sight a lighted candle, placed at a moderate distance, will perceive these little luminous lines of light crossing all the series of filaments which the mineral contains. According as the stone has a four or six sided form, we have a four or six rayed star, and if the filaments are all in one direction we have a luminous band.

In scratching with the point of a diamond a plate of glass in various directions, we produce bands of light of the same number as the traces upon the surface, which are always in a transverse direction to these traces. We can even very simply produce a star in spreading with the finger a little wax or grease upon a plate of thin glass. It is necessary

for this that the coating should be very thin so as merely to dull the glass, and that the finger should be moved directly across—for example, from right to left, or from above downward; then looking through it at a lighted candle, there will be seen a band of white light crossing the direction of the lines of tarnishing. If the same operation is performed in two directions on opposite sides of the glass, then a four-limbed cross will be formed by the two luminous bands which cross each other before the eye.

Ceylon produces a greenish stone traversed by filaments of white amianthus, which is called the *cat's-eye*, and which is usually cut spherically and quite prominent. We see in it a floating band, which comes from the play of light on the lines of amianthus within it. In general with these curious accidents of light exhibited by exceptional stones, the color of the starry radiance should contrast as much as possible with the tone of the stone itself. In simply scratching crossed lines on a beautiful carnelian, I have succeeded in producing a white cross on a red ground. In minerals this starry quality is very valuable, because it reveals the primitive form of the substance in which it is found, and I repeat that, by looking through a stone suitably cut, we find these luminous transverse bands in a great variety of crystallized minerals.

There is a very hard dust employed in the arts, called *emery*, a powder used in rubbing or grinding down bodies with hard surfaces. This substance is a species of corindon or sapphire, containing a tolerably large proportion of iron, which has been substituted for the aluminium at the time of the formation of the stone. This substitution is quite common in chemistry and mineralogy. It is believed that the Chinese succeed, by patience, in cutting diamonds with emery. This must be very slow work, because the stone of which emery is composed is very much softer than the diamond; it is like sharpening steel by rubbing it on paper or linen. However, if patience can work miracles, it is doubtless reserved for the Chinese to accomplish this result.

We shall place after the sapphire, the *opal*, which comes from Hungary and Mexico. The Hungarian opals are much the superior, and have not the disadvantage of deteriorating with time. Some years ago the opal was higher in price than the sapphire; but increase in value inducing a more active working of the mines, the price of opals, beautiful as they are, fell to what we find it at present. For the perfection of an opal, it should exhibit all the colors of the solar spectrum, disposed in small spaces, neither too large nor too small, and with no color predominating. The opal is sometimes called the harlequin, in allusion to the great variety of colors which it displays. The substance of the opal is of a milky hue and of a pale greenish tint. This milkiness is generally known by the term *opalescence*. It is the color of water in which a little soap has been dissolved. In order to explain the brilliant colors of the opal, we may imagine in the stone a great number of isolated fissures, of variable width, but always very narrow. Each fissure, accord

ing to its width, gives a peculiar tint similar to the effect produced by pressing two plates of glass together: we may recognize violet, blue, indigo, red, yellow, and green, the last two being exhibited more rarely than the others.

As a proof that the brilliant colors of the opal are due, as we have said, to narrow fissures, similar colors may be produced by partially fracturing, with the blow of a hammer or a wooden mallet, a cube of glass or even a rock-crystal. Colors obtained in this way are known in optics by the name of colors of thin plates, and are of the same character as those of flowers, which result from the overlaying of the transparent tissues of which the petals are composed. Herein lies the secret of all their varied hues from their first opening until their final decay.

Sometimes the opal is colored only in its substance, has not so great a play of light as when it is variously traversed by fissures, and then it is not so much esteemed. Again, it may have extended fissures exhibiting a somewhat changeable single color—red, blue, yellow, or green. The Empress Josephine once paid a very high price for a pair of these stones, it being then the fashion to wear two bracelets exactly alike, and it was quite difficult to get two stones perfectly matched, since the interior disposition of the fissures of the opal, which gives its peculiar play of color, depends entirely upon accident. At present it is only the *harlequin* opals that are much valued, and those of Josephine would not now bring a tenth of their former cost.

Except for ear-rings, the opal should be set singly, with or without a surrounding of small brilliants, whose vivid lusters and scintillations contrast favorably with the tints of the opal.

The opal is not a very hard stone. In its chemical composition it is only hydrated quartz—that is, white pebble, combined with water. Heat, expanding its fissures, varies its colors, and pressure obviously produces the same effect. I have thus often changed, without permanent alteration, the colors of a beautiful Hungarian harlequin opal.

Before the revolutionary tempest, in the closing years of the past century, the financier d'Augny possessed a harlequin opal of great beauty. It was a perfect oval, 21 millimeters long, and from 15 to 16 millimeters in breadth. Esteemed as entirely perfect, the stone had a great celebrity. I do not know if d'Augny ran, like the senator Nonius, any risk of proscription during the years of terror; but certainly if he did, it was not on account of his possession of this unparalleled opal, since the wretched tyrants of '93, who sold to foreigners the treasures of St. Denis, and of many other churches, for 80,000 francs, did not dream of opals exhibiting all the colors of the rainbow.

The opal of d'Augny, the value of which I have nowhere seen estimated, passed some time ago into the hands of Count Waliski. The opal of Nonius, of the size of a hazel-nut, which he selected from among all his treasures as the companion of his exile, was estimated at 20,000,000 sesterces, which, according to the exact table of M. Dureau de la Malle,

in his book on the Political Economy of the Romans, is about 4,000,000 francs. Now, if we recollect that before diamond-cutting was understood, the opal was the only stone which, receiving the white light of day, gave it back refracted in a thousand magic tints, this price does not appear too much for a gem which was the *Koh-i-noor* or the *Regent* of Rome. The opal, at the same time that it is the lightest of all gems, losing in water one-half its weight, is also one of the softest. Those of India are somewhat superior in these respects.

In actual value the Paris market places, next after the opal, two stones of an undecided greenish yellow, viz, the *chrysolite* and the *peridot*. The first is characterized by its lively luster, its polish, analogous to that of the sapphire, and its warm bright tint. It is the "stone of affection" of Sir David Brewster, so celebrated for his researches in optics. The chrysolite, or *Cymophane*, has often the milkiness of the sapphire. To enumerate its other properties we must enter the broad field of modern optics, speak of double refraction, of polarization, and the colors which are exhibited in the light which traverses crystals, and finally of the three kinds of colored rings, namely, those with black lines, those with black crosses, and those without either lines or crosses. The rings in the chrysolite, as in the topaz, are of the first kind. This is not, however, a distinguishing property, since it can be made to appear, with a little dexterity, in almost all cut stones. As to the *peridot*, or *olivine*, its color is deeper than that of the chrysolite; it is always of a greenish olive, mingled with yellow, the green predominating; is very soft, scarcely scratches glass. Its lack of hardness gives an appearance of dullness to its edges. The *peridot*, which comes to us from India, is there used as ornaments of harness, as well as are the flatly cut emeralds of the same country. Ceylon, which is above all other places distinguished for the production of colored stones, does not continue to furnish the peridot, which, however, is not rare in the lava from volcanos, although the specimens are too minute to be worthy of the art of the lapidary.

I have often seen in the possession of an amateur interesting collections of these small crystals, which, viewed by lamp-light and under a microscope, verified all the crystallographic laws of Haüy. A crystal of a peculiar property, though of the minutest dimensions, was to this eccentric amateur what the *Star of the South* would be to an ordinary collector of diamonds. His long and minute investigations gave him great facility in the study of minute gems. From a stone covered with small crystals he would select one which, under the microscope, and properly lighted, would present the most interesting scientific indications.

The *peridot* has the distinguished honor to be the only precious stone that has thus far been found in aerolites falling from the sky, although these little olive stones are of no great value if sold by the carat; but if suitably cut in their matrix, they afford, if not very beautiful, certainly very curious, specimens. I need scarcely say that the existence of a crystallized stone found in bodies falling from the atmosphere refutes the

idea that these meteorites are formed suddenly by the condensation of exhalations from the earth. The regular disposition of the particles of a substance in the form of a crystal requires immense time as well as perfect freedom of motion.

From the *peridot* we pass to the *garnet*, which is a ferruginous stone of a deep-red color, and often wanting in transparence. It is, however, sometimes found of the beautiful color called peach-bloom. To the perfection of colors it is necessary that a specimen should join a regularity of tint, wanting which constitutes a defect easily perceived by an eye properly trained. There is sometimes found with cut garnets a very pretty assemblage of stones in juxtaposition, which gives a very agreeable appearance of black mingled with red. The only garnet I have ever seen of any value is the *hyacinthe*, a stone of a luscious orangy yellow color, having a little the appearance of candy made of brown sugar. This stone, which Haüy wrongly separates from garnets, is not much esteemed except by amateurs or collectors of curious specimens. The Hollanders formerly cut garnets into a pearl shape, which were strung in necklaces and used as money among the slave-traders. As in sapphires, *astérs* may be observed in garnets, and I have been able to verify, by the cutting, all that this phenomenon indicated of the structure of the stone.

In the garnet can be developed crosses with six and also with four limbs, besides straight and oblique crosses, without counting certain circles of light resulting from a cutting perpendicular to the *astérial* filaments.

Both for mineralogy and also for optics the study of gems affords many important facts. It is to the study of mineralogical optics that Malus, Arago, Fresnel, and Biot, in France; Huyghens, in Holland; Wollaston and Sir David Brewster, in England; and Seebeck and Haidenger, in Germany, owe so much of their renown, and to which the science of light is indebted for its most beautiful discoveries.

Pliny gives no Latin name to the garnet, but confounded it with all stones of a red color, under the head *carbunculi*. It is the heaviest of gems, and like the diamond does not possess double refraction. From the white garnet of Norway very excellent microscopic lenses have been made, although it is ordinarily from the diamond that small and exceedingly powerful lenses of this kind are formed. The cutting of such lenses is very difficult, and the price commensurate with the labor and skill required in the operation. I may here observe that another mineralogical crystal having single refraction, the *amphigène*, strongly refractive and perfectly colorless, may also perhaps be used to form small, powerful lenses.

The *topaz*, whose name is derived from its yellow color, is a mineral which also crystallizes in prisms, and is susceptible of being very nearly broken transversely. They are of all colors, and come principally from Brazil and Saxony, though Siberia also furnishes them. The price of

the yellow variety, which, strictly speaking, only ought to bear the name of *topaz*, has wonderfully declined during the last quarter of a century. The Brazilian topaz cannot be confounded with the oriental, which is a beautiful corindon of a yellow color, deepening almost to orange.

Although the topaz is not considered a very brittle mineral, it is said that the Emperor Maximinius, who broke the teeth of his horse with a blow of his fist, and the leg of a beast by one of his royal kicks, was so strong in the hands that he could crush topazes as we crush a lump of sugar. The topaz has been for a long time a great favorite, especially with the Spaniards, but with the caprice of fashion it has of late years greatly declined in the estimation of the public.

It was on the white topaz of Brazil that Fresnel made the important discoveries of double refraction with two axes. It is, also, the topaz which bears the name of water-drop, which is made so often to pass for the diamond. In mineralogy this stone serves as one of the types of comparative hardness. Thus, we say a stone scratches glass, scratches rock-crystal, scratches topaz and sapphire, according to the various degrees of hardness. For example, the Brazilian topaz cannot scratch sapphire, which is one test of a diamond. The black diamond of Borneo scratches every stone, even diamond itself. As to the *peridot* and *opal*, they scratch nothing, not even ordinary bottle-glass, which I use in experiments of this kind; as to window-glass it has become too soft of late to be used as a test, since for economy it is now made with too large a proportion of alkali.

The blue topaz of Brazil has never as deep a tint as that of the sapphire; it is only an aqua-marine of superior quality. Of all topazes, the only one highly esteemed is that artificially colored, of a pale rose hue, by means of fire. For the specimens that we wish to experiment with we must choose those of a deep yellow or rich orange color. Afterward they are placed in ashes or sand and submitted to a red, or even a white heat, more or less prolonged. When they are taken out we find the tint changed to the light red of what is called *ruby balais* or *ruby brulée*, (burnt ruby.) The gay color of this ruby is very pleasing to the eye. A dilettante once remarked to me, "This stone has an amiable character." I was entirely of his opinion as to the moral of this gem, although there is certainly nothing very *sincere* in the means by which it acquires its beautiful tint. If, like the olivine, the topaz had been enveloped in volcanic fires, it would naturally have become a *ruby balais*, and no cloud would have rested on the truthfulness of its character.

The mineral species which the topaz forms is characterized by a certain quantity of fluoric acid, which it contains exclusively of all other gems. This stone, moderately heated, becomes electric and will attract light movable bodies. A delicate linen thread, suspended vertically from one end, is attracted by the warmed topaz as it would be by a stick of sealing-wax after being rubbed on cloth. The topaz shares this curious

character only with the *tourmaline*. This latter stone, of which we shall say very little as a gem, is highly prized in optics on account of its polarizing qualities, which are utilized in a great variety of apparatus. It is without any brilliant luster; and though proposed as a stone for mourning ornaments, to compete with jet, jewelers have not yet made up their minds to employ it for this purpose. For a really rich mourning-decoration, black diamonds are the gems to be used, as they have been in Portugal in decorating the crown-royal. The earliest specimens of tourmalines came from Ceylon through Holland. The red tourmaline of Siberia, called also *sibérite*, is pretty enough for a ring; it occurs in minute crystals. The amateur of whom I have spoken had in his collection very small *sibérites*, from Corsica, of a crystalline form and exquisite in color; they would have served as gems for the decoration of the Liliputians. There are beautiful green and blue tourmalines, which come from South America, and are called Brazilian emeralds and sapphires. The aqua-marine, the name of which indicates its sea-green hue, is a stone of a mineralogical character similar to that of the emerald, but little in demand at the present time. It is possible that there may be an augmentation in its price, since no new ones are received in market. This stone loses nothing of its appearance in artificial light, and it is sometimes curious to see a magnificent decoration of sapphires wanting in effect at night, while a cheaper one of aqua-marine is not only preserving its splendor, but seeming to gain in brilliance by candle-light. The English regard aqua-marine with the partiality the Spanish had for the topaz.

This stone takes a beautiful polish, and preserves it for a long time. It is less hard than the topaz, and possesses many optical qualities, on which our limits will not permit us to touch.

We come next to the *amethyst*, the name of which signifies a *specific against drunkenness*. It is a true rock-crystal of a beautiful violet color; it is essentially a daylight-stone. Nothing is wanting to this lovely gem but rarity. Pliny employs the word amethystize as synonymous with violetize. Modern savans, with their lynx-eyes, find a difference between violet rock-crystal and pure amethyst. The latter is characterized by a series of little undulated strata, which is wanting in the violet rock-crystal. There are specimens of colorless quartz which have a structure similar to that of the amethyst. When certain agates consist of very thin layers of a uniform thickness, they take the colors of the spectrum, and are called iridescent agates. It is probable that the myrrhine vases, whose value reaches some hundreds of thousands of francs, were cut from iridescent agates. Sir David Brewster has given the exact theory of this iridescence, ignorant that I had already done so before him in the reports of the Institute.

The same philosopher has also demonstrated that the color of sea-shells is also due to their surface being striated by undulating and closely approximated minute lines; for, if we take the impressions of

one of these shells in finely prepared wax, we get the colors as well as the form of the specimen. Myrrhine vases were sold at 70, 100, and 300 talents. The talent was about 540 francs. We may find among minerals many stones which, being cut, will make excellent gems. There is the euclase, a weak emerald in color, but not so hard as a real emerald. The *amphigène* is as pretty as the white sapphire. The prehnite is a tolerably good *céladon*. It is somewhat remarkable that researches in mineralogy have led to nothing new in the way of precious stones. This illustrates a remark of Humboldt that mineral nature is the same from one end of the world to the other, which cannot be said of either the vegetable or the animal kingdom.

There is no hope, then, of our finding anything beyond diamonds, rubies, sapphires, topazes, emeralds, and amethysts. The only resource is the laboratory. To obtain new gems man must not count upon nature but upon his genius.

In terminating the list of precious stones let us say a word about the white pebble or rock-crystal. This is nothing but flinty sand, crystallized and variously colored. Almost all false gems, so called, are made from rock-crystal or quartz. Thus rock-crystals, cut like the diamond, as Rhine diamonds and Alençon diamonds, are called false diamonds. It is only violet quartz which makes the true amethyst. Recently an attempt has been made, with considerable success, to imitate the yellow topaz with rock-crystal of the same color. There is developed in the stone a very rich, velvety, orange color. As to all the reflections, the tints, the degrees of transparence, or of opalescence—in fine, of all the forms which quartz, a veritable proteus, can assume, a volume would hardly suffice to detail them. Formerly rock-crystal was used for chandeliers and many other articles for which glass is now substituted. The ancients were cognizant of the power balls of rock-crystal possess to concentrate the sun's rays and of setting fire to bodies. Physicians also used them to cauterize certain wounds, in accord with the adage, "After medicine, the knife; after the knife, fire; after fire, nothing." These balls can likewise be employed as microscopes, especially when they are small. Minute nature might have been studied as well by the ancients as in our day had they been so inclined.

I have not mentioned turquoises, of which there are two kinds, both without transparency. One of these is made from the teeth of the mastodon and colored with copper, a *green céladon*. It is a kind of fossil ivory. The other is a true mineral of the same greenish blue color, and is a great deal admired; it costs about forty francs the caret. The turquoise is perfectly imitated by porcelain. This stone, without transparency, can scarcely be reckoned among gems; it is rather a kind of natural enamel. We have also omitted feldspar, which contains an alkaline principle, and which yields stones having a mother-of-pearl luster, but without colors. However, when feldspar is

of a golden-yellow tint, covered with little reddish spots, it is cut like a gem, but is at the present time very little known; it is called *aventurine.*

After the consideration of crystallized minerals in nature, we should attempt the imitation of them in the laboratory. I do not mean such imitation as paste and color produces. I refer to the reproduction as nature gives the gems to us, and propose the making of real precious stones, such as has been attempted in the case of the diamond. I have already said that Ebelman, at Sevres, has crystallized aluminium and silex thus making a true *spinella.* M. Despretz, in the experiments by which he has volatilized charcoal and the diamond, has also melted aluminium and silex. He has obtained from these substances little hollow spheres, lined inside with crystals, like the cavities which are found in mines containing crystals of various kinds. In all the experiments of Despretz, the exceedingly intense heat which he produced by electricity only served to dissipate the particles of the diamond without producing any crystallization. It is therefore evident that the diamond is not an igneous production. Its origin is probably electric; but what was the epoch of its first production from ordinary carbon, and where did its crystallization begin?

According to M. Boutigny, the carbon of the earth comes from showers of hydrogen, united with carbon, which watered as it were the earth when it was too hot to receive ordinary rains. We have not yet seen the bearing of this hypothesis on the crystallization of the diamond. I have already said that sulphur and carbon, in uniting together, produce a liquid as limpid as water or pure alcohol. Now, with this it might be well to try the following experiment: Having filled a strong iron bottle with the liquid, and having covered it with an iron stopper, firmly screwed into the neck, I would place it in an oven at 200 or 300 degrees centigrade of heat. At this temperature the iron of the bottle and the sulphur would possibly react upon each other and enter into combination. Now, the sulphur, uniting with the iron, would leave the carbon free, which might thus slowly arrange itself in the crystalline form. I merely propose this experiment, which might require a long-continued heat of uniform temperature, to illustrate the play of chemical affinity. It is possible the effect would be analogous to that which takes place when a porous body is plunged into a saline solution, which absorbs the water and leaves the salt crystallized on its surface. We should inform those who may be tempted to try this experiment, that the fluid within the bottle would acquire by heat an immense repulsive force, sufficient to break almost any vessel inclosing it, especially one of iron, after the metal has been acted on by sulphur. The old alchemists frequently met with serious accidents in their attempts to transmute mercury by overheating it in closed iron vessels.

We have just said that there is very little chance that nature will furnish us with any new minerals. We must therefore depend on the results of the laboratory, and examine every substance whose hardness,

polish, transparence, and crystallization render them suitable for gems. We may afterward discover the method of coloring them, which would not seem a very difficult task, from the fact that the coloring-matter is always a foreign substance, and that, in many cases, gems have already been artificially colored. Ebelman, by evaporating ether from silica, has obtained beautiful specimens of paste, exactly resembling opal. Though man may never be able to discover all the processes of nature in the production of objects of curiosity or practical utility, yet he is every day inducing her to disclose some of the secrets of her operations, either as she reveals them spontaneously in the changes of the earth or is forced to repeat them under the coercion of her own agents—heat, light, and electricity.

ETHNOLOGY.

ON THE LANGUAGE OF THE ABORIGINAL INDIANS OF AMERICA.

By George Gibbs.

Among the questions submitted for consideration at the meeting of the American Philological Convention in July, 1869, was the following: "What more efficient measures can be taken to preserve from destruction the languages of the aboriginal Indians of America?" This communication embodies the substance of my individual views, as then offered, and I now take the liberty of presenting them to your consideration in the belief that the Smithsonian Institution possesses the only appliances adequate to the task.

The introduction to this topic might suggest an account of what has already been done in the collection of materials on those languages; but this would involve a multitude of details, chiefly the names of books, to criticise which would be out of place. A very full catalogue of all dictionaries, vocabularies, grammars, and grammatical notices prior to the year 1858, was compiled by Dr. Hermann E. Ludewig, and published in London by the Messrs. Trübner, with corrections by the late Professor Turner. From this it appears that, with the exception of a comparatively small number of languages, out of over thirty distinct families enumerated by Mr. Gallatin, and not including those of Texas, New Mexico, Arizona, or the Mexican States, there are no grammars or dictionaries worthy of those names. Of the rest of those north of the present Mexican line nearly all that we have consist of mere word vocabularies, such as have served for the comparisons by which the various families have been distinguished. These are for the most part confined to the forms adopted by Mr. Gallatin, and are either of sixty or at most one hundred and eighty words, too few to allow any but very close affinities to be recognized, and many of the words ill adapted even to that object. Without disparaging labors of this kind, a very necessary preliminary to further examination, it is certain that they do not fill the requirements of philological science at the present day. The collections already published, and those in manuscript in the possession of the Smithsonian Institution, soon to be put to press, cover nearly the whole of the American and British possessions, with the exception of a few New Mexican pueblos and some scattered and unascertained tribes. With the publication of these last, what may be considered as the primary classification of the Indian tribes in those territories, on the basis of linguistic affinity, is about complete. To go beyond this some new standard is required.

I would suggest, in the first place, the preparation of a far more copious vocabulary, to be based on the ideas exhibited in the languages already known. The words should be arranged not alphabetically but according to subjects, as the only mode consistent with intelligent inquiry, and as permitting the distribution of special or local words; for instance, objects familiar to one nation and not to another. Such a vocabulary should consist of not less than fifteen hundred words, and an even greater number would be advisable. In selecting these words, particular reference should be had also to such as are radical or contain radicals, and plain instructions be given by which the collector, if he has leisure and inclination, may dissect them.

Secondly. A large number of well-digested phrases, based upon these words, calculated to draw out the different forms of speech, and from which the grammatical structure of the language can be deduced.

Thirdly. The preparation of a succinct and popular statement of the most striking peculiarities of some of the different languages as derived from grammars already published and of well-known authority. No one who has ever attempted, for the first time, to acquire an Indian language but has been foiled, over and again, by a want of knowledge how to direct his inquiries; and the most intelligent student has labored for a long time without success, where a slight clew would have guided him. Although there are certain characteristics which pervade almost all American languages, they yet differ greatly from one another in the degree in which these are marked, and often in the method in which they show themselves. Some languages, also, have evidently reached a far higher degree of culture, so to speak, than others. In fact, there is as much difference in the grammar and syntax of different Indian languages as in those of the Indo-Germanic stock. In many of them a modification of the numerals takes place according to the nature of the object counted, sometimes indicating whether the object is animate or inanimate, at others various other qualities, as form, &c.; and the number of these modifications varies from two in the Selish (one applied to the first, the other to the second class) to over forty in the Cakchiquel. In the Otchipwé, or Chippeway, language, on the other hand, where the nouns are all divided into animate and inanimate, there are a variety of changes in the cardinals, but none on that principle; while in their place there are certain numeral verbs which are animate or inanimate according to the object expressed. In the Cherokee this principle is not found either in the nouns or numerals, nor are the latter modified at all; but the modifications, which are numerous, including animate and inanimate, are confined to the verbs, many of which change according to the quality of the object in which the action terminates. For example, the verb "to take" is in English simple, no matter what is the nature of the thing taken, but in Cherokee there is one form signifying to take a pliable object, another to take a long object, others to take a liquid, an upright, or a living object, and the particles indi-

cating these go through all the conjugations, moods, tenses, numbers, and persons. It will at once be seen under what difficulties the student labors who is not forewarned of these modifications.

It would, of course, be unwise to swell a work intended for popular use, with all the nice distinctions of these languages, but it is desirable that the main features of some leading ones be pointed out; and in my opinion the best arrangement would be to take each part of speech consecutively, and to show those features as varying in different languages. Those persons who have time and leisure for closer and more intimate study could afterward refer to more elaborate grammars.

Such guides, in the nature of instructions, "How to Observe and What to Observe," should, of course, be disseminated widely through the Army, among missionaries, agents, surveyors, and other persons residing in or traversing the Indian country. It is hoped that in this way a stimulus may be given to the exertions of many who only require to know in what direction to employ their leisure and tastes.

In order to the fit preparation of complete and exhaustive works on the indigenous languages, it is, however, necessary that there should be fit collectors in the field. Among those who have given most time to the actual study of our linguistics but few can afford to devote themselves to procuring new material. It is chiefly by missionaries, and by the Catholic priesthood especially, that the most valuable works on the subject have been prepared. Willing collectors of vocabularies have not been wanting, but of trained men there are few or none.

It appears to me that to accomplish any thorough and satisfactory result, an attempt should be made to prepare the laborers. It is possible that a foundation may hereafter be created for a professorship in some leading college where the teaching of American philology will form an important item, if not its exclusive object; but that would, at best, reach only a few individuals. Some wider method must be adopted to instruct a larger number. There has, as yet, been little or nothing of "Universal Grammar" taught at any of our institutions. Grammars of special languages are taught, it is true, but with hardly an attempt to show the common sources whence these are derived, or to exhibit the phonetic changes undergone in the lapse of time and under physical influences, or to trace back the ideas which have developed, from single roots, words of widely different signification, and none at all to develop the principles lying at the root of all speech.

It is very true that in a short collegiate course, pursued for the most part before the mind has become mature enough to grasp at more than the facts of language, and where utility is the presumed basis, it would be impossible to include such training to any considerable extent, but the course might yet be pointed out for after-inquiry. When the time comes—and it is to be hoped it will before the last vestiges of the aboriginal tongues shall have disappeared—in which general grammar becomes a common part of education, the curious modes of thought

presented by the American natives will doubtless excite the interest of the student, and every opportunity be sought of gathering up their remains. How many languages which have arisen since primeval man first trod the earth have perished from its face, each indicating, to a certain extent, in its mere words and forms, not only the outward circumstances in which those races moved, but the degree of their mental culture and the character of their thoughts. Ethnology has no surer basis than an intelligent philology. One of the least functions of the latter is to bring together or distinguish races.

There is one important point on which I have said nothing. I mean the alphabetic system to be adopted. I am clearly of opinion that the Roman and Italic letters should be used wherever practicable, and that they are in most cases sufficient. The alphabet prepared by Professor Whitney for the Smithsonian Institution is simple and intelligible, though in particular cases it needs supplementing. Foreign characters and redundancy of diacritical marks are objectionable on many grounds. It is the difficulty with most systems, as with that of Lepsius, that they are beyond the comprehension of any but their inventors, or at least require too varied a knowledge and too great nicety for any practical use. When a work is undertaken by a European, other than an Englishman, it is better, perhaps, that he should write as in his own tongue. That will carry a definite meaning at least to those who understand its pronunciation, and will insure a degree of certainty not otherwise to be relied upon. The explanation, in writing, of unusual sounds is always a hazardous experiment.

The preparation and publication of such a vocabulary, phrase-book, and grammatical guide as I have indicated would, it seems to me, properly come within the objects of the Smithsonian Institution, and I feel assured, from the interest you have always manifested in original philological research, that the subject will at least meet with consideration.

ON ANTIQUITIES IN SOME OF THE SOUTHERN STATES.

By H. C. Williams.

Near Vienna, Virginia, *December* 30, 1869.

Agreeably to promise, I send to the Institution a few specimens of Indian arrow-heads, all that I have been able to collect. I regret that the number of perfect ones is so small.

In Franklin County, Tennessee, in the days of my youth, when the country was fast filling up by emigrants from the older States, Indian relics, such as broken pieces of pottery, pestles, axes, heads of war-clubs, and arrow-points, were of frequent occurrence. There was no memorial in that part of the country to induce a belief that it had been inhabited by any race of aborigines, but the general diffusion of the articles above

named may be received as satisfactory evidence of its having been a hunting-ground to some not very distant village or encampment. The burial-mounds near Chattanooga and Sparta indicate those places as headquarters of the tribes for a long duration of time.

The fragments of pottery were generally of a dark color, not very hard or compact, with white specks mingled through the mass as though small pieces of shells had been mixed with the clay, and had not been converted into lime by the process of burning. The pestles and other implements were fabricated from stones of different colors, apparently of a clay basis, and corresponding, in appearance, to rocks which are common to the Blue Ridge. No such rocks occur between the Apalachian chain and the Rocky Mountains. The arrow-heads were made from quartz, which of this kind is not found in that country, the siliceous minerals, except the sandstone, being more or less cherty, with a semi-conchoidal fracture, often associated with and sometimes embedded in the limestone below the coal seams. Rarely an arrow-head of this mineral was discovered.

The mounds near Chattanooga have been already noticed by your correspondents. I would it were in my power to direct attention to another interesting locality. Of this my only knowledge is obtained from a publication, I think in the year 1825, in the *Review*, a newspaper printed at Sparta, the seat of justice of White County. As well as my memory serves me, Dr. Fiske and some other gentleman made an examination of an ancient cemetery near that town, and, finding no remains of adults, came to the conclusion that the country had been inhabited by a race of pigmies. The graves were numerous, covering more than an acre, were generally three feet long and eighteen inches deep, with a "coffin" of slaty rocks. The bones were so much decomposed that they fell to pieces after a few moments' exposure to the atmosphere. Perhaps a file of the *Review* for that year may be in the Department of State, for in it were published the laws of Congress, and it was then the custom of the Department to bind and preserve such papers. I mention this to enable persons investigating Tennessee antiquities to avail themselves of the information furnished by writers who observed and described those interesting objects before they were changed or obliterated by the hand of civilization. In this connection no book will be so likely to arrest the attention of the curious as Haywood's History of Tennessee. It is to be regretted that this, one of the earlier books published beyond the Alleghanies, is now so scarce in the State where the author was one of the first and ablest of its jurists.

In closing this communication, intending in another to notice the locality of some mounds and fortifications not alluded to by any of your correspondents as I have seen, I will state that when on an excursion into the State of Arkansas in the year 1857, I came to a place where doubtless an immense number of arrow-heads had been manufactured. It was near the summit of a ridge about two miles north of the Hot

Springs, and west of the road that passes over the ridge. At that place there is an outcrop of the *milky white* variety, an intermediate stratum of the celebrated Arkansas *novaculite*. There the hill-side for about one hundred yards in length was literally covered by thin chippings of that mineral. Dr. Sibley and Dr. Dunbar, who explored the Arkansas, Washita, and Red Rivers during Mr. Jefferson's administration, mentioned in their report that they had discovered a place where Indian implements had been made. I have not seen the report for many years, and cannot say whether this is the locality alluded to by them, but think it is, for they were at the Hot Springs, and there is not another mineral in the State so well adapted as the *novaculite* to this purpose. This is the only place in the Southwest that I have seen which affords any evidence of the fabrication of implements used by a people whose history is unknown. At Santa Fe, in 1858, a gentleman showed me several arrow-points that had been formed out of the *obsidian* found in that country, and a few days afterward, in the village of Casa Colorado, I gathered up a small quantity of that mineral in thin flakes that had obviously been chipped off in fashioning arrow-heads. By careful attention to the mineral characteristics of those ancient implements, especially when composed of as rare minerals as the *novaculite* and *obsidian*, we may be able to trace the migrations of the people who used them.

The report of Dr. Sibley, no doubt, can be found in the congressional documents of the period or in the reprint of them by Messrs. Gales and Seaton. It contains information that would be appreciated by persons engaged in ethnological or philological researches. Among other things it states that two tribes of Indians, the Natchez and Tensaws, if my memory is correct, were at war, that one party was disastrously defeated, and escaped over the Mississippi into Louisiana. On making a halt, the first thing they did was to throw up a mound. This is the only record that I have seen of a mound being constructed within traditional history.

ETHNOLOGY OF THE INDIANS OF THE VALLEY OF THE RED RIVER OF THE NORTH.

By Dr. W. H. Gardner,

Assistant Surgeon United States Army.

The earliest explorers of Minnesota found the Dakotas occupying all this country they now roam over or have only lately ceded their title to. In prehistoric times what race dwelt here cannot be told; the burial mounds and crumbling skeletons, the "refuse heaps" and fragments of rude pottery, point to some branch of the "mound builders," but whether Nahoas, Toltecs, or Aztecs, will probably never be known.

About Big Stone Lake, Lake Traverse, and the west bank of the Red River of the North and the country adjacent, for many years past, the

Sisseton and Wahpeton bands of Dakotas have resided; almost as rude and ignorant as the lowest branch of the Athabascan stock, yet they are tractable and show a desire for bettering their condition. Their manners, customs, and language do not differ essentially from the other bands of the great Dakota Nation, save from the aberrant branches, the Yanktonais and Tetons; neither can those bands understand the Wahkantans, Wahpetons, Wahpecutas, the Wabashaw band, the Black-Dog band, the Red Wing band, &c. The language used by them is constructed on the well known polysynthetic plan, and is so well known that one or two dictionaries have been published of the language.

Polygamy is common among them, each brave having as many wives as he chooses and can support, but lately some of them have embraced the Christian religion and have "put away" all their wives but one. Their Christian system, ingrafted upon their former fetichism, has resulted in a curious mongrel theology, which would puzzle even Buddha to understand. They have the same cruel instincts that always characterize a race of hunters; hardly one has come under my observation that has not more or less of small scars upon the body, purposely made with fire or cutting instruments, to show they have "brave hearts," yet my experience with them in sickness has been that they bear necessary pain quite as badly as even negroes. Their tribal government is a rude democracy, if that can be called a government whose most binding law is the *lex talionis;* nor do they recognize any head or chief save him who is bravest in war and most persuasive in council. Their legends and traditions are too well known to require only passing comment. Some of them are pleasing and instructive; but the most of them are puerile beyond description, and it is very hard to tell what purpose of national or social economy they could possibly subserve. The most of them are detailed at length in "Mrs. Eastman's Legends of the Sioux."

Of the arts of life they are almost entirely ignorant; even the ceramic art, with which most of savage tribes are necessarily acquainted, they are now ignorant of, though it would seem that before their communication with the whites they knew something of this art and used pottery made by themselves to cook their food in. After communication with the whites, and a knowledge of metallic vessels for the purpose of cooking, the art of making pottery was gradually neglected until it has now been lost. At all events the Indians of these bands know of no way of boiling their raw food now save by digging a hole in the ground and covering it with the skin of an animal recently killed, into which are poured the water and the food to be cooked; stones are then heated in an adjacent fire and held in this novel pot until the meat is done. As to their cooking, Professor Soyer, Monsieur Blot, or the most wonderful *chef de cuisine* that ever raised a pot lid, would stand amazed to see the wonderful heterogeneous mass combined to make one of their *ollas*—beasts, birds, reptiles, and fishes, berries, herbs, and roots, thrown together into the pot all in *purus naturalibus,* and stewed into a disgust-

ing paste. And the amount of this one of these "sons of the forest" will eat, will cause even an anatomist to wonder at the distensibility of the human stomach.

Until 1861 those about this locality—chiefly Sissetons—lived entirely by hunting and fishing. About this time some of them were furnished corn and potatoes by their agent, and they commenced to cultivate the soil, but shortly afterward, from causes not relevant to mention here, the Dakota outbreak occurred. The Sisseton and Wahpeton bands were implicated with the others, and the distrust and animosities this has necessarily engendered have much delayed their civilization.

The men are rather over medium height, are well made, and many of them are intelligent-looking, some even handsome. The type of their heads, with their "low defective forehead," the vertical occiput, the prominent vertex, and great interparietal diameter, hardly need mention, though it is deserving of remark that the "low defective forehead" is not so characteristic of the crania of the Sisseton band as of some of the other bands of the Dakota Nation. Their shades of color show considerable variation; many of them on the parts of the body not habitually exposed are not darker than many brunettes with us, while others in the same band are of a deep bronze or even coppery brown color. As a rule their hands and feet are small and delicately formed, and as a people they are remarkably free from deformities. Their hard "struggle for existence" probably acts on the principle of "natural selection" to keep up the best and hardiest of the stock, while the weaklings and the deformed die off. I have seen but one deformed Indian during my stay here. He was a Wahpeton with a simple case of "hair lip," which its owner refused to allow me to operate upon. They are enthusiastic and excitable gamblers, and will stake their ponies and even their wives on a game of "moccasin." The females are short in stature and broad and more ungainly than the males; they possess great strength and great power of physical endurance, as is commonly the case among uncivilized tribes, where the women are the drudges and slaves of the males. I am inclined to the belief that the females arrive at the age of puberty before the age usual among civilized females. I have seen one Sisseton girl who was the mother of a healthy child—which she was nursing—when but thirteen years of age, and two or three who were mothers before they had quite attained the age of fourteen; though this precocity may be caused by the promiscuous intercourse of the sexes in their rude manner of life. Writers have spoken of the dreary existence of Dakota women, and nothing that has been said can draw too exaggerated a picture of the never-ending drudgery of their lives, uncheered even by the hope of happiness in the spirit land; therefore suicide is very common among them; even for trivial causes a Dakota woman will cut a thong of buffalo hide and hang herself. A case came under my observation a few weeks since where the wife of one of the

scouts here hung herself to the ridge-pole of her tent just because her husband told her she should not make a visit which she wished to do.

Under the provisions of General Order No. 27, Headquarters Department of Dakota, St. Paul, Minnesota, dated May 19, 1867, friendly Indians have been enlisted as scouts and guides, since which time fifteen of them have been on duty at this post in that capacity. Those here are all full-blooded Indians of the Sisseton band of Dakotas. They are ambitious and zealous in the performance of their duties, and take a pride in keeping their clothes, bedding, equipments, arms, and horses neat and in good order, and I believe this is the testimony which all their commanders will give; and it shows that they can be made valuable auxiliaries in prosecuting warfare against Indian tribes "avowedly and obstinately hostile." Those on duty here show no repugnance or even disinclination to work, and the scouts have taken their regular tour of "police duty" with the rest of the enlisted men, and have shamed them by their willingness to do this duty.

One of the scouts here is tattooed with a "totem" of an open right hand, back to the front, placed vertically in the center of the forehead. This is the only instance which has come under my observation of any tribal or family mark or "totem" among them.

The Chippewas occupy the country east of the Red River of the North, in Minnesota, about the lakes forming the source of the Mississippi River and Red Lake farther north. Though they are occasional visitors to the post, they are situated too far away to be described as Indians about the post.

The valley of the Red River of the North on both sides is the peculiar habitat of half-bloods, (Bois Brulés, or Couriers des Bois,) a mixture of the blood of the lawless white traders (who until recent times were the only white people in the country) and Indian women. These half-bloods, the result of this mixture, are tall, well formed and hardy, with dark eyes and swarthy skin, and black, straight hair, though occasionally one is seen with the hair curly. The general shape of the head and face is much like the Indians. Their vernacular is a *patois* of the French, though they usually speak the language of both parents. They are natural-born hunters and trappers, scouts, guides, and interpreters, and are a valuable link of communication between the tax-paying citizen and the untamed red man. These people have no "local habitation;" like their half-brothers, the Indians, they live in tents of tanned buffalo hide, which they move whenever and wherever inclination or the pursuit of game may lead them. They have the same freedom from moral and social restraint as the Indian. They eat anything and everything, even the flesh of dogs and wolves poisoned with strichnine, and think a fœtal calf of cow or buffalo *une bonne bouche;* they wallow in dirt and vermin, and are remarkably healthy and tenacious of life. Their severe, laborious lives probably prevent them from being very prolific, but it also acts to make them healthy and long-lived. Even syphilitic diseases, which (with

the loose virtue of their women) it would seem would be particularly prevalent, do not appear to attack them at all. At least, not one of these cases among them has been brought to my notice.

ACCOUNT OF ANTIQUITIES IN THE STATE OF VERA CRUZ, MEXICO.

By Hugo Finck, of Cordova.

A few general remarks relative the traces left by the aborigines of this neighborhood may not be uninteresting. As a resident of twenty-eight years in this part of the country, (Cordova, Huatusco, and Merodor,) and during my many botanical excursions, I have had good opportunities to examine them. These traces are of two kinds—the first belonging to a semi-barbarous; the second to a half-civilized people, who, for a long period of years, must have lived together as neighbors, but in a state of continual dissensions.

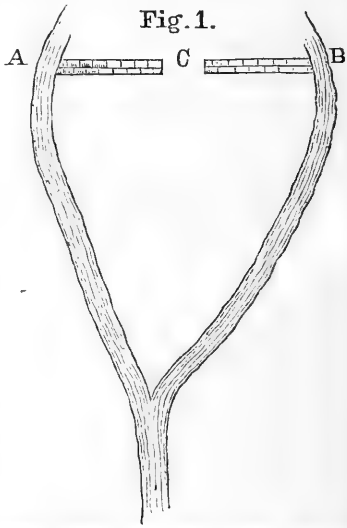
Like the actual descendants of the Aztecs, the semi-barbarous people built their houses, or rather huts, of light timber, covering the roof with palm-leaves or dried grass. Nothing else was required by them in a tropical climate, where the thermometer never descends below 55° Fahrenheit. Of such constructions no trace whatever is left, and if it were not for the innumerable mounds of stone of different dimensions, some united, others isolated, and which were always annexed to their dwellings, we would come to the conclusion, either that they had no dwellings, or that the country was very thinly inhabited. The very contrary was the case. There is hardly a foot of ground in the whole state of Vera Cruz in which, by excavation, either a broken obsidian knife, or a broken piece of pottery is not found. The whole country is intersected with parallel lines of stones, which were intended, during the heavy showers of the rainy season, to keep the earth from washing away. The number of those lines of stones shows clearly that even the poorest land, which in our days nobody would cultivate, was put under requisition by them; furthermore, when we consider that their implements of agriculture were very primitive or almost null, requiring a so much larger space of ground for their sustenance, we must come to the conclusion that the population must have been immense, or at least as large as the most populated districts of Europe. In this part of the country no trace of iron or copper tools has ever come under my notice. Their implements of husbandry and war were of hard stone, but generally of obsidian and of wood.

The small mounds of stones near their habitations have the form of a parallelogram, and are not over twenty-seven inches high. Their length is from five to twelve yards, their width from two to four. On searching into them nothing is found. A second class of mounds is round, in the form of a cone, always standing singly. They are built of loose

stones and earth, and of various sizes; some as high as five yards, with a diameter of from five to twenty yards. Excavation made in them brought to light a large pot of burned clay filled with ashes, but in general nothing is found. The third class of mounds, also built of loose stones and earth, have the form of a parallelogram, whose smaller sides look east and west, and are from five to six yards high, terminating at the top in a level space of from three to five yards in width, the base being from eight to twelve yards. They are found from fifteen to two hundred yards long. Sometimes several are united, forming a hollow square, which must have been used as a fortress. Others again have their outer surface made of masonry, but still the inside is filled up with loose stones and earth. Near river-beds, where stones are very abundant, these tumuli are largest. Principally in this latter class, idols, implements of husbandry and war are discovered, sometimes lying quite loose, and at others imbedded in hollow square boxes made of masonry.

The last-described mounds form the transition to those constructions, which are altogether built of solid masonry. I speak only of such as are found near Cordova, Huatusco, Cotastla, &c., in the state of Vera Cruz. One peculiarity of the last-mentioned ruins is, that they are all constructed at the junction of two ravines, (barrancas, cañons,) Fig. 1, and used as fortresses, on account of their impregnability. Most of the larger barrancas have precipitous sides from three hundred to one thuosand feet deep, which guarded the inhabitants on their flank, so that nothing more was required than to build a wall from A to B, leaving a small entrance in the middle, C, as a passage, which could be barricaded in time of war. Between Zacuapan and Tlacotepec, at the Rancho del Castille, at Matlaluca, at Cotastla and Consoquitla, such constructions can be seen to this day in tolerable good condition. The interior of these fortified inclosures is in general large, sometimes holding from four to five square miles, and could be put under cultivation in case of a siege.

Fig. 1.



The wall A B is in general from four to five yards high, and has on the inside terraces with steps to lead to the top. At other places there is a series of semicircular walls, the front one lower than the following, and a passage between each to permit one person at a time to pass from one to the other. The innermost wall is sometimes perforated with loopholes through which arrows could be thrown.

Quite a number of ruins are found inside the fortification, as mounds,

altars, good level roads with a foundation of mortar. Most of these monuments have good preserved steps leading to the top. In some very small pots of burned clay are found filled with ashes.

Between the simple mounds of loose stone and earth and the last-mentioned monuments we may easily discern two classes of people—one semi-barbarous and the other tolerably advanced in civilization—living continually at war with each other, impeding on that account a higher grade of civilization than that found at the arrival of Cortez with his Spaniards.

Civilization in all countries has been very gradual and must always have commenced in warm climates. It was in Asia, in Africa, in the tropical parts of China, Syria, Egypt, &c., where we find the oldest monuments, where the people as far as 3,000 years back had made some progress. The inhabitants of colder countries were, up to that time, in a barbarous state, and only received civilization by contact with the others or by conquest. This may be accounted for in the following manner: The first knowledge we have of man is in a tropical climate. It is there where vegetation the whole year round is luxuriant; where fruits of all kinds are abundant, furnishing him with food without exertion; where a hot climate dispenses with all covering against cold; where the first necessities once satisfied he had leisure, if endowed with a lively imagination, which is natural to people of hot countries, to set his wits to work in order to better his condition. One step followed another, creating daily new necessities. Those of a strong arm imposed on the weaker, and obliged them to work for them or for the community. In this way civilization gradually advanced.

Now let us transfer ourselves to a cold country. Its primitive inhabitants had to guard against the weather in winter, which obliged them to become hunters in order to slay the wild beasts which were to serve them as clothing as also to allay the cravings of hunger. Wild fruits could only be gathered in summer and autumn, and were much less abundant than in the tropics, so that their whole time was occupied in attending to the necessities of their existence, or in guarding against the cold of winter, being continually slaves to their wants, leaving them no leisure to better their condition. History has shown that such has been the case throughout all cold countries, and that civilization made very little progress there until the inhabitants came in contact with more southern nations. The same has happened in America. Where do we find the traces of higher civilization on this continent? Is it in British America, in New England, in Oregon, or in Patagonia? No! In tropical America. The same causes have created the same effect. Peru, Ecuador, Yucatan, and Mexico, all countries between the tropics, have taken the first steps toward advancement. The yet existing monuments speak for themselves.

From Palenque, in Yucatan, and Quito, in Ecuador, as centers, civilization spread north and south, but found much greater resistance by

the neighboring savage tribes than in the old continents. In some hot countries, as Guiana, Brazil, topical reasons have retarded this; as yearly inundations; excessive number of insects, particularly mosquitoes; wild beasts, &c.

After the first progress of civilization the neighboring savage tribes, among which we may count the Aztecs, who appear to have been in nothing different from our contemporary Comanches, Arapahoes, Sioux, &c., made, like of old the Scandinavians, irruptions on their more southern neighbors, destroying again partially what had been gained, but accepting part of the advantages of their conquered people. The inhabitants of Central America were much farther advanced before the dissemination of those barbarous tribes than at the arrival of Cortez. This is shown by the ruins still in existence. It was a great misfortune. Those savages, less docile than the Goths, were slow in receiving the advantages of their conquest. Accustomed to a roaming life, expert in war, they destroyed in a few years what had cost thousands to build. Then commenced a reign of terror. The vanquished were obliged to work for their conquerors, creating those rude monuments, as the stone-mounds, the pyramid of Cholulu, and other similar works, which could only have emanated from the brains of half-savages, and been executed by a people completely enslaved. But this had its limit. The conquerors gradually accepted such benefits from their vassals as suited them, so that if the Spaniards had not arrived, civilization would have taken a new start, as at this time the Aztecs were strong enough to keep at bay all new irruptions from the north.

Aztec hieroglyphics are too obscure to give us a longer insight into their history than for a century or two at most. Spanish historians have given free scope to their lively imagination, exaggerating and distorting whatever came under their hands. The Spanish clergy seized and burned what could throw any light on history, and wrote about what best suited them. The real and only true documents we can with safety count upon are the monuments, ruins, implements of industry and war, which are yet in existence; anything else will only lead us astray.

CCOUNT OF ANTIQUITIES IN TENNESSEE.

By E. O. Dunning.

Chilhowee, Tennessee, *June* 19, 1870.

The territory recently explored by myself lies along Little Tennessee River, in Blount County, Tennessee, and extends about twenty-five miles into North Carolina, a country once inhabited by the Cherokees. One of their principal routes from the south to the "Over-hill Towns" passed through it. For miles the old trail may be seen crossing Chilhowee Mountain in a straight line, according to the Indian course, between

two points, which was always direct, without regard to obstacles. Lately I had an opportunity of observing this peculiarity. While winding my way around the base of a mountain in North Carolina, I saw some Cherokees going to the same point as myself, right over the crest of the mountain, by a more direct but more difficult route.

Chilhowee derives its name from two words, which mean fire and deer. The Indians were accustomed to hunt by fire. At night they carried before them torches—blazing pine-knots—in the face of their game, which, becoming frightened by the glare, were easily brought to a stand and killed by the hunter, who, resting his gun across the left arm, held the torch in his right hand until the deer was enough terrified to be shot down. The old trail over Chilhowee is used now by the "mail-boy" once a week, and by foot-travelers like myself, who are warned not to take horses beyond the mountain for fear of their being stolen.

In Chilhowee Valley, after crossing its northern boundary by the pass, I examined two mounds on the left bank of Little Tennessee and several rock graves, or tombs, near them. These tombs are unlike any depositories of the ancient dead that I have observed. They were, undoubtedly, constructed by the "mound-builders," as similar ones were discovered in the mounds containing similar relics. The great freshet of 1867 uncovered a large number of these graves on the "river-bottom" or alluvial terrace, which had been plowed over for seventy years. They are built of slabs of slate, nicely fitted together, about three inches thick, four feet long, and two feet broad, inclosing receptacles, not of uniform space—generally five feet long, four feet high, and two feet broad—covered with flat pieces resting upon the upright slabs, and conforming to the rounded corners of the tomb. The material had been brought from the other side of the river, as no slate was found in the vicinity of the constructions. They were found to contain, for the most part, fragments of human bones, too much decomposed to be removed in considerable portions, implements of stone, and broken vessels of clay. From the head of one I extracted a vase of black pottery, nearly whole, shaped like a gourd; it had been filled with vegetable matter, which, perhaps, was intended to sustain the spirit on its journey to the other world, some flint arrow-heads, and a stone pipe. Charcoal, ashes and burned clay indicated that fire had been used in the burial, by which bones and many other relics were consumed.

Judging from the form and size of these graves, the dead must have been inclosed in a sitting or crouched position, often bent nearly double. The bones were those of adults, and their juxtaposition, in some instances, showed that they could not have been deposited indiscriminately, after the decomposition or removal of the flesh, according to the custom of some modern Indians. Fragments of the skull-bone, with teeth and jaws, were found at the head of a grave which pointed toward the west, and the bones of the foot at the other end. In connection with the first were vertebræ and other portions of the trunk and cor-

responding members of the skeleton, which had crumbled and fallen down together, and which would naturally occur if the body had been set upright or slightly bent over.

I did not expect to find rock graves in a mound of earth, but after clearing away rubbish and penetrating six feet below the top, near the center, the workmen struck a slab of slate, which proved to be part of the covering of a stone tomb. It was much like those scattered over the "river-bottom"—more nicely constructed, however, and fitted with more care—being arched over the top, at an acute angle, with pieces of slate three inches thick. Owing to its situation, raised above the level of the river and covered with sand to the depth of six feet, its contents were better preserved than those of the graves just mentioned. At the head of it I took out a vessel composed of fine red clay and pulverized muscle-shells, a foot in diameter, gourd-shaped, having a handle and spout six inches long, and holding about a quart. It was preserved nearly whole. Artificial fire had been kindled in the tomb, but it had been smothered by the throwing in of sand before all the contents were consumed. Besides some entire bones of the human skeleton, flint arrowheads and a large number of shell and stone beads were removed. The beads could be traced along the lines of the legs and arms, as if they had been attached to the garment in which the dead was buried. Further excavations disclosed two more of these stone sepulchers, the first three feet below the one described, the other two feet from it, in the same plain. They contained only fragments of bones, charcoal, and ashes.

The mound, which was conical in shape, must have been fifteen feet high and fifty feet in diameter. Successive floods had impaired its original dimensions. The last carried away a section on the west side, exposing a tomb and some valuable relics, which have not been preserved. Among them were large shells—pyrulas, probably, judging from the description, from the Gulf of Mexico—such as I have discovered in two other mounds on the banks of the Tennessee, and which are deposited in the Peabody Museum of Harvard College. In connection with marine shells, images in stone were found in this tomb. The mound was composed of sand-loam taken from the bank of the river and raised upon a foundation of water-washed rocks, four feet high from the bed of the stream hard by. There had been extensive burnings throughout this mound, at various depths, indicated by layers of charcoal, ashes, and burned clay, simply in honor of the dead or to consume their effects and mortal parts, or for human sacrifices to their manes.

As no relics, except fragments of charred bones, not even stone implements, that would escape destruction by fire were found, after careful searching among extensive layers, I am inclined to the opinion that captives in war were freely slain and burned, for a sacrificial offering to the dead in the tombs. It is not probable that a people so particular about their burial-rites, as shown not only in the mound-sepulchers, but in those scattered over the plain, which we may suppose contained their

common dead, would have assigned a large number of their tribe, after death, to a promiscuous or general conflagration. Fire, as is well known, bore an important part in the obsequies of the "mound builders," but so as to show neither in the extent and composition of the charred layers, nor in the kind of relics preserved, the design of the burnings. Two other mounds were found in Chilhowee Valley, which will be described at some future time. The tradition, as derived from a lady over eighty years of age, who lived in her youth among the Cherokees, is, that these mounds were made by a people inhabiting the country long before the recent Indian race; that their fathers found them there and did not disturb them, a statement which confirms all oral testimony respecting those monuments.

Leaving Chilhowee Valley and crossing the Alleghany range toward North Carolina, in a southeast course, having Little Tennessee River on my right and occasionally in sight from the cliffs, my attention was called, along the road, to "stone heaps," a class of antiquities not often mentioned and seldom distinguished in books. After an examination of the objects and a talk with Indians and the oldest inhabitants, I came to the conclusion that there were two kinds of these remains in this part of Tennessee, which are sometimes confounded, viz, landmarks, or stone-piles, thrown together by the Indians at certain points in their journeys, and those which marked a place of burial. At a pass called "Indian Grave Gap," I noticed the pile which has given its name to the mountain-gorge. The monument is composed simply of round stones raised three feet above the soil, and is six feet long and three feet wide. As the grave had been disturbed I could make no satisfactory examination of its contents. On the opposite side of "The Gap," a stone heap of another description was observed, which had been thrown together in accordance with Cherokee superstition, that assigned some good fortune to the accumulation of those piles. They had the custom, in their journeys and war-like expeditions, at certain known points, before marked out, of casting down a stone and upon their return another. In this way, in time, a landmark became a conspicuous object. It may be distinguished from grave-stone heaps, which were composed of large round stones of uniform size; the other of small stones, of no particular shape, such as could be easily taken up and hastily thrown down. Four miles from "Indian Grave Gap," on the west side of my path, on a ridge destitute of vegetation, I observed twenty-five of these stone heaps which covered human remains. I examined a number of them, which were four or five feet high and eight in diameter, and shaped like a hay-cock. Trees three and four feet thick had grown and decayed on some of them. In one I found pieces of rotten wood that had been deposited there, fragments of bones, and animal mold. The deposit had been made on the surface of the earth, covered with wood and bark, and crowned with a cone of round stones. From the center of one heap three small bells were extracted, having the letters J R engraved on them. They much

resemble sleigh-bells of the Northern States, and must have been obtained from Europeans having intercourse with the Indians. The bells were used as "tinkling ornaments" by Cherokee women in their dances, and were attached to bear-skin belts that were bound about their limbs.

The great number of rattle-snakes that I encountered on the ridge prevented a thorough examination of the place in the heat of summer, an employment that may be resumed at a future time.

The stone heaps were put up, undoubtedly, by the Cherokees of a recent period. My researches did not throw much light upon their antiquity, but they were found to differ essentially, in structure and contents, from the rock tombs of the "mound-builders," already described, and they must have had a later origin.

The Cherokee custom of burying the dead under heaps of stone, it is well known, was practiced as late as 1730. After free intercourse with the whites their custom of inhumation prevailed with the natives. Considering the dilapidation, the condition of the animal remains, and the decay of vegetation that indicated the former growth of trees of more than a century, I regarded those piles that came under my observation as being two or three hundred years old. The bells, silver ornaments, and coin discovered in them belong, of course, to the age of metals in this country, which may have begun on the banks of the Little Tennessee more than three hundred years ago. In 1690 trading-stations were established there by northern adventurers.

ACCOUNT OF ANCIENT MOUNDS IN GEORGIA.

By M. F. Stephenson, Gainesville, Georgia.

The most extensive and perfect tumuli exist in Bartow County, on the Etowah River, near Cartersville, consisting of ten mounds, situated in the bend of the river, and protected from attack on the land side by a moat, which is from twenty to thirty feet deep and was doubtless once filled with water. The central mound is square, and measures one hundred and fifty feet on the top,* with raised platform on the east side twenty feet high and forty wide, evidently where sacrifices were offered, as an idol of sandstone was plowed up on it, with excavated disks or mortars six inches in diameter and of translucent quartz of elegant workmanship, the stone axe, a small native copper vessel, the perforated shell, (which is found in all the mounds,) the mica mirror, and the only gold beads ever found, native gold being found in the neighborhood. This mound is eighty-eight feet high, and a few rods from it is a circular one, sixty feet high, which twenty years ago had a parapet on top five feet in height. The remainder are small and only about twenty feet high. Two points in the ditch are excavated an acre square as deep as the

* It is not exactly a quadrangle, but the north side is 150 feet; the eastern, 160 feet; southeastern, 100 feet; south, 90 feet; and the western side, 100 feet.

moat, to procure earth to raise the mounds. The valley and country for thirty miles westward and northward is very fertile, and exhibits evidences everywhere of having been densely peopled by the mound-builders.

At the falls of Little River, near the Alabama line, on the crest of the fall, are three chambers hewed out of the solid sandstone; and at Nacoochee the crest of a conical hill was cut off at about fifty feet, so as to embrace an acre and a half, which on two sides is quite precipitous, and on the others has a ditch and wall, which was formerly six feet high, inclosing about twenty acres. This was doubtless used by De Soto in the battle he had with the Cherokees in 1540, which is proved by the relics which have been found.

At Macon are stupendous remains, as also in Campbell County, on the Chattahoochee. The Yond Mountain, four thousand feet high, of solid granite, is a cone, crested with trees, but perpendicular on all sides except one space, which was walled with stone; so was the Stone Mountain, which is, without exaggeration, two thousand three hundred and sixty feet high, a cone, and accessible on one side only; this was walled with stone. All defensible mountains in this country were fortified. Neither the Cherokees, Creeks, nor Seminoles had any tradition of this extinct race, which is proved to have been a powerful and despotic nation from the extent of their territory and the stupendous character of their fortifications and cemeteries.

EXPLORATIONS IN TENNESSEE.

By E. A. Dayton.

Knoxville, Tennessee, *April* 9, 1868.

I left this place on Saturday last, and reached the house of Wm. Staples, in Roane County, on the evening of the same day. I went via Cross's Ford of the Clinch River; thence via Robertsville. The distance is about twenty-eight to thirty miles. Staples's farm is on the west side of Poplar Creek and on the line of Anderson County. On Monday I made an examination of the salt well or lick, and the Indian remains spoken of in the newspaper article I sent you. They are located a mile south of west of Staples's house, one-fourth of a mile from Poplar Creek, and on a small branch, in which the water was about three inches deep and four feet wide; it flows between hills, and a well is at the base of one of the hills which is about one hundred or one hundred and twenty-five feet high. The rock is a clay shale. The well is about five to five and a half feet in diameter, and is full of water to the top, which is about on the same level as the water in the branch. There was little or no water flowing from it. It was possibly a little brackish or sulphurish, but very little of either. The well did not appear to be *stoned up*, but

to have been dug through the loose shale rock. I ran a pole down into the water and mud from twelve to fifteen feet, and it did not then touch hard bottom. A quantity of logs and sticks had lately been taken from the well; they were much decayed. On the opposite side of the branch, and a little down it, say about sixty to seventy-five feet from the well, were Indian remains. They covered a space of about thirty by fifty feet, and about three to four feet above the water in the branch. The soil is a vegetable mold from six to eighteen inches deep, through which are found fragments of earthen-ware, ashes, and burned stones. I dug a trench, twenty feet long and as deep as any remains were to be found, along the center from one side of this place. The bottom of the branch is the shale in place, and there is no deep soil, that about the well being about a foot deep, made up of loose stone. This place was pointed out to me by Mr. Staples as being the one spoken of in the paper, and where he had found fragments of earthen kettles of a diameter, as indicated by their curvature, of over three feet. Half a mile east of the dwelling of Mr. Staples, on a low ridge, and about the same distance west of Poplar Creek, are three mounds. They are on nearly a straight line north and south, and one hundred and fifty feet apart. The south one is fifty feet in diameter and six and a half feet high, round and oval on top. They have all been plowed over for several years; very small fragments of bones are found about them now, and I was told that human remains were plowed up on all of them. I dug a trench across the center of the south one, nine feet long, seven and a half deep, and two wide; I went below the streak of black soil the mound was built on. The earth of the mounds is of the same color as that in the fields on all sides, only it was streaked a little with darker colored earth. The middle one of the mounds was only about four feet high; I did not dig into it. The north one was about sixty feet long from the southeast to the northwest, of an oval shape, and about forty feet wide. I dug down into this one about three and a half feet, and found nothing. In the fields I found a quantity of arrow-heads, but not a particle of pottery. A third of a mile to the southeast, on lower ground, is another mound a little larger than the first one described. I did not dig into it.

I left Mr. Staples on Tuesday morning, and traveled via the old salt-works, three miles up the creek from his house. Salt was made here years ago, before the completion of the railroads; and Staples made some there during the war, using the coal obtained from the hills only one-half to three-fourths of a mile from the well; but as the brine is weak it does not pay now to work the well. I reached the house of Alfred Cross, on the west side of Clinch River, and five miles down it from Clinton, about noon. I had heard of the finding of many Indian relics on the opposite side of the river, on the lands of George and John Johnson, they having been washed out of the soil on the river-bottom by the flood of last year. I crossed the river and went to the house of C. R. Robins. A negro man in his employ had found and gave me the shal-

low round dish I send you, and the soapstone pipe. The piece was broken out of the side after it was found. Of Robins's people I also got the jar, and the smaller jug, or whatever it may be called. I then went to the Johnson's; they had had two larger vessels than these, but let the children use them for playthings, and they broke them up. Jerry then showed me to the place on the river where these things had been found; the water is now twenty-five to thirty feet below the level of the bottom, and it was covered, judging by the marks, along the higher land, six to twelve feet deep. Along this bottom, for one-half to three-fourths of a mile, and for one hundred to three hundred feet from the bank, every yard of the soil has fragments of pottery, burned sandstones, and shells, and flint fragments, but I did not find a single arrow-head here. At the lower end of this bottom the water washed out the soil three to five feet deep in spots, covering from one-half to one acre. In these pits were found these vessels. I could see along the banks of these pits that the remains reached to a depth of only twelve to sixteen inches. The soil did not appear to have been washed off only where these pits were excavated; nor was there any appearance of mounds, and I was told that there never had been any on this bottom. Last year the field was in corn; this year, wheat. Many of the specimens of earthen-ware appear freshly broken, as if done in plowing. I saw many very small fragments of bone, and I believe that there is now a large quantity of these earthen vessels buried in the ground, for these I have, must have been buried, and for a purpose. The owners would certainly have thrown away only the broken ones. I had no time to dig, and only stopped my surface search at dark. Wednesday I traveled up the west bank of the river to Alfred Taylor's. Here the water had washed the soil off of some three to five acres, and there were great quantities of burned sandstones, fragments of flint, &c. Very few fragments of earthen-ware were to be seen here. Here Mr. Taylor said that the flood of 1862, which was much greater than that of 1867, washed out many articles, bones, &c.; one, a stone jar, some person carried away, as well as many other things; but I could not hear of any of them being in the neighborhood at the present time. You will see by the large fragments of soapstone that they likely made vessels of that article. I hear of other places, one Watson's Island, where there were many articles washed out by the flood, and there are a great number of mounds along the Tennessee and its branches; and if there are any questions in regard to the mound-builders yet unsolved, I think this country the place to solve them in. Did they bury their dead in the bottom or on the top of the mounds; or did they bury them in or near their villages; and did they bury one of the jars or pots with them; or was something hidden in the buried vessels? I think that nothing but careful digging will solve these questions.

SOME ACCOUNT OF THE SARCOPHAGUS IN THE NATIONAL MUSEUM NOW IN CHARGE OF THE SMITHSONIAN INSTITUTION.

By Rear-Admiral A. A. Harwood, U. S. N.

Washington, *December* 17, 1869.

I recognize this sarcophagus as one of two monuments removed from elevated grounds just in the rear of Beirut, in Syria, and embarked on board the United States frigate Constitution, the flag-ship of the Mediterranean squadron, of which I was at the time first lieutenant. I left the ship shortly after, and on my return to the United States learned from reliable sources that one of the sarcophagi referred to had been presented by Commodore Elliott to Carlisle College, in Pennsylvania, and that the other, after having been offered to General Andrew Jackson to be buried in, and the old hero's declining the honor, was deposited in the Patent Office as the tomb of the Emperor Alexander Severus.

As you have probably observed, there is no inscription on this coffin, (to give it its English name;) consequently who the occupant was, or what his position, is a subject of pure conjecture.

The somewhat profuse carving upon it might suggest that its former tenant was "well to do in the world," but the style is hardly chaste and simple enough to encourage the supposition that he or she was of imperial or patrician rank. Nevertheless, for nearly twenty years this relic was exhibited in a public building of the metropolis, labeled as the last resting-place of the Emperor Alexander Severus, and nobody took the pains to question the accuracy or expose the absurdity of the legend.

It was found *near* to the one referred to as having been presented to Carlisle College, which is inscribed with the name of "Julia Mamaea," and in virtue of that fact assumed to be the coffin of the Roman Empress of the same name, and the wish thus becoming "father to the thought," the contiguous receptacle was incontinently credited as having contained the mortal remains of her imperial son.

Any respectable coffin in the same grave-yard would have had as good a claim to the honor of having inclosed an emperor; but after all, the first step to be taken should have been to ascertain who the Julia referred to by the inscription was. She might have been a relative of the Empress, the mother of Alexander, both because the Empress was of a Syro-Phœnecian family, and because the style of the sarcophagus, incorrectly represented as hers, is simple and elegant, and such as might have contained the bones of the kinswoman of an empress, but the inscription, which I copied carefully at the time, very conclusively establishes the fact that she was not the Empress Mamaea. It runs as follows:

IVLIA. C. FIL.
MAMAEA
VIXIT. ANN. XXX

which, if I have not lost all my Latin, means Julia Mamaea, daughter of Caia, lived thirty years.

The Empress Julia Mamaea was not the daughter of Caia, but of Julia Soemias; the legend on her tomb should therefore be I. FIL, and not C. FIL. Then she was killed in Gaul with her son Alexander, in a mutiny of the soldiers, on the same day.

According to the best authorities, he was just thirty years old when this event took place. None make him more than thirty-three. Assuming the least probable as the date, then, if the sarcophagus at Carlisle College be that of the mother of Alexander Severus, she must have given birth to her son when she was but three years old, which is, to say the least, unusual.

In brief, that the sarcophagus now deposited at the Smithsonian Institution was taken from an ancient cemetery at Beirut, in Syria, and brought to the United States by Commodore J. D. Elliott, in the frigate Constitution, and by him deposited in the Patent Office, and thence transferred to the Smithsonian Institution, would be a plain and truthful label to put on the relic.

ACCOUNT OF THE DISCOVERY OF A STONE IMAGE IN TENNESSEE, NOW IN POSSESSION OF THE SMITHSONIAN INSTITUTION.

By Edw. M. Grant.

Nashville, Tennessee, *August* 12, 1868.

The history of its discovery is as follows: Near Strawberry Plains—a station of the East Tennessee and Virginia Railroad, about sixteen miles east of Knoxville, Tennessee—there is a cave, one of the many hundreds of those natural curiosities that are to be found in the belt of country lying between the Ohio River on the north and Northern Mississippi, Alabama, and Georgia on the South, the Mississippi River on the West, and the Atlantic Ocean. This cave is in the direct line of march of De Soto's expedition to the Mississippi River; many of his forts, and other traces, being still visible at the present day in that section of country. In the early spring of 1867 I had a force of men building the large bridge over the Holston River at Strawberry Plains; and during one of the various visits that I made to the work I saw this stone image, which had just been found in the cave referred to, about one-half mile from its mouth, I think, by a man named Douglas, who was wandering about in the cave one Sunday. It was attached to a stalactite or stalagmite at the back of the head, where a fresh portion of the rock can now be observed, evidently having been chiseled from one of the formations mentioned, an operation that required considerable skill and patience, as the red Tennessee marble, which it is cut from, is very hard, and its crystalline formation renders it very difficult to carve. Douglas

was away from home at the time, and consequently I could not obtain it from him. My evident desire to possess it, however, attracted the attention of my foreman, Mr. B. F. Price, and after Douglas returned Price purchased it and sent it to me by express as a present.

It has been examined by several persons who have paid considerable attention to Indian antiquities in the South, and none of them has ever seen anything like it. Traditions here indicate that the tribes who inhabited this country were not idol-worshipers; still, this may be erroneous. The cave in which this image was found has never been explored. I believe the inhabitants in the neighborhood are too superstitious to make many explorations in such places, and the finding of this image did not tend to allay their apprehensions; consequently there may be many other traces of the worshipers of this idol in the mazy passages of this subterranean labyrinth. Very few of the immense numbers of these caves have ever been thoroughly explored. Some of them have been traced many miles, and hundreds of passages, in every direction, discovered, but no termination was reached in any of them. I have been in one of these caves that I think surpasses the far-famed Mammoth Cave of Kentucky.

I believe that the belt of country referred to in the beginning of my letter is richer in interesting features of geology, mineralogy, antiquities, &c., than any other section of this continent. It is a region that never has been scientifically surveyed, and promises a rich field for the naturalist, geologist, and mineralogist, as well as the antiquarian.

ON MIXED RACES IN LIBERIA.

By Edw. D. Blyden.

[The writer of the communication from which the following extracts are given is a pure negro, a native of St. Thomas, and now professor in Liberia College. The letter was addressed to a member of the board of directors of the American Colonization Society.—J. H.]

Monrovia, *October* 6, 1869.

My Dear Sir: I send inclosed a catalogue of all the students who have ever been in Liberia College. It will be seen that not only were they not natives, (aborigines,) but more than three-fourths the number have been largely mixed with Caucasian blood, and among these death and disease have made sad ravages.

The great practical difficulty in the way of succeeding with our schools is the lack of suitable teachers. It is sad to relate that notwithstanding the thousands of dollars spent annually here by the different missions for educational purposes, there are still but very few teachers to be found, especially among females, able to conduct properly an elementary

school. The reason is that pains and money have been bestowed upon persons largely mixed with Caucasian blood, who, if males, have mostly died, or if females, have got married and assumed the cares of a family. It seems that the females of mixed blood, who are not obliged to put forth much exertion, and not subject to much exposure, last longer than the males. It appears, also, that mulattoes born and brought up in America, if they can pass through the acclimating process, stand the climate much better than those born here, but only by engaging in as little physical or mental labor as possible. Persons having an admixture of foreign blood are very frail, easily take cold, and seldom recover from a severe attack of illness. This will account in part for our want of enterprise and progress here. Such men have had the lead and management of things, and, by the fearful example of their disastrous inactivity, have been obstructive guides, discouraging all energy and *go-aheadativeness.*

Before the question of race came up here, mulattoes died just as they do now, but it was not noticed. Their mortality was put down to the general unhealthiness of the climate. But since Professor Freeman, in his address of July, 1868, called the attention of the people to the startling history of mixed breeds on this coast for the last two hundred years, the mixed classes have been watching with alarm the numerous indications of the frail tenure of their existence.

I have been for the last eighteen years connected with educational matters here, and feel safe in giving it as one reason why we are no better off in men to take charge of schools and churches, that the attention of educators has been principally devoted to persons of feeble constitutions.

The idea was that the presence of white blood imparted greater aptitude for learning, and such persons were to be fitted for teachers. Black boys of hale and hearty *physique* were left to grow up unnoticed. Many of them have taken to sea-faring life, or gone to reside as permanent traders among the natives, who might now be active workers in our destitute fields. But with all the advantages afforded to the miscegens, still the only professors for the college yet produced in Liberia are pure negroes; and the only man with enterprise, energy, and talent enough to explore the interior, calculate distances, and construct a map is a pure negro; and in the future, if we have any scientific men here, botanists, mineralogists, chemists, &c., they are sure to be pure negroes, and perhaps from the native tribes.

But what has become of the half and three-fourths white *protegés?* In the Alexandria high-school we had Armistead, Miller, Fleming, Melville, Augustus, Fryzon, Samuel D'Lyon, Colston, Waring, James H. Roberts, all are dead. In Liberia College, we have had James H. Evans, J. J. Roberts, jr., Beverly Russell, J. T. Chambers, John Henry, J. H. Harris, Edmund J. Payne, all dead. J. W. Leone is a raving maniac, and may die at any moment. In connection with this, I would

like you to read a letter which I wrote last year to Mr. William Tracy, of New York, dated September 11, 1868. Facts, it is said, are God's arguments. I venture to affirm that if the names I have just cited had been negroes, three-fourths of them at least would have been living to-day; for in all that space of time I know of only one negro connected with either institution who has died, N. R. Richardson, of sunstroke.

Now, who is to blame for these things? No one in the past; but if they are continued in the future, after God has presented his arguments, then those who continue them must be blamed. I do not charge guilt upon any one in the past, for I believe that these things were not done at the instigation of wrong passions, but under the delusion of a false theory. And you, gentlemen in America, proud of your race and blood, have thought, perhaps, that it must, as a matter of course, endure here, when strengthened by a negro basis, and bring to the negro an accession of improving mental qualities. But your theory has not stood the test. So far as physical health and vigor are concerned, I would rather take my chance here as a pure Caucasian than as a mongrel. The admixture of the Caucasian and negro is not favored by Providence in inter-tropical Africa, whatever may be the case in America. Let me beg you to look at this matter at once before wasting any more thousands upon an impracticable scheme. God does not intend that the Egypt of America shall be reproduced in this African Canaan. If persons who are half and three-fourths Egyptian could live and thrive here, if the families whose disappearance and extinction I have noticed in my letter to Mr. Tracy could have lived and carried out their views, and gratified their tastes, we should long since have had a miniature Egypt here with its caste feelings and prejudices.

The friends of the negro in America must learn to believe that the negro can exist and prosper without the aid of white blood in his veins.

Now that slavery is abolished in America, and the blacks are being educated, it is to be hoped that all good men will discourage, as far as possible, the "miscegenation" doctrine. The negro race is injured by it far more than the white, for by prejudice the nondescript progeny is consigned to our side, even if they are three fourths or seven-eighths white, and thus involve us in an inextricable "muddle." This is certainly a vexed question. But the higher plane to which the American people have attained by the recent revolution has given them loftier views and wider sympathies, and has furnished the means of education for the negro, which will supply the transition process from his low estate to a more intelligent and respectable position. Respect for the negro is becoming more and more, in the progress of events in America, the happy distinction of our age. The negro is being taught to respect himself, and soon he will think it no honor to mingle his blood with that of the Caucasian, Indian, or Mongolian.

ON SHELL-HEAPS.

By Rev. James Fowler, of New Brunswick.

I have lived for a number of years near the coast, but have never enjoyed the pleasure of discovering any of these heaps, and, as the result of my inquiries, have come to the conclusion that none such are to be found along the shores of this county or the neighboring county of Northumberland. Their absence may be accounted for by the fact that the whole coast is very low, and, being composed of the soft sandstone shale of the carboniferous formation, is constantly wearing away by the action of the waves. Within the last ten years the sea has encroached several rods upon the land. At Bay du Vin a church was erected about fifty years ago at such a distance from the shore that it was thought the sea could never reach it, (the bank or cliff being ten feet high,) but the church toppled into the sea five or six years ago, and the burial-ground that lay around it will soon have disappeared. Ten years ago a single storm, in October, removed the coast-line from four to five rods inland in exposed situations, and changed the appearance of long stretches of the shore. If shell-heaps ever existed on this coast, they must long ago have been swept away by the constant encroachments of the sea. Again, there are portions of the mainland protected by outside beaches running parallel with the coast and separated from it by distances varying from a few rods to a mile. These are composed of loose sand, and are continually changing their positions, owing to the action of winds and tides, so that any heaps that may have accumulated on them must have been buried or swept away long ago.

The coast of the Bay of Fundy is composed of harder rocks than our coast, and is consequently better fitted for preserving any deposits on the banks. I do not see, however, why heaps should not be found in some of the more sheltered bays or recesses of the coast, but I have not yet been able to discover their existence.

I have made inquiries about the stone implements of the aborigines, and have succeeded in securing two arrow-heads and an ax. Several have been found in this locality; but as those who find them are ignorant of their value, they never think of preserving them, and they soon disappear, or are broken up by children. Should these I have be of any service I can forward them.

I regret that I am incapable of furnishing you with more positive information, but negative conclusions are sometimes valuable.

ON THE USES OF THE BRAIN AND MARROW OF ANIMALS AMONG THE INDIANS OF NORTH AMERICA.

By Titian R. Peale,
United States Patent Office.

The uses of the brain and marrow of animals among savage people having become of interest in connection with the ethnological researches which are being prosecuted with so much ardor in this and other countries, a brief exposition of the facts relative to the subject, observed by myself, and collected from the writings of others, may not be unacceptable for the Smithsonian report. It may not, perhaps, be improper to state, as introductory to the subject of this communication, that I am, with one exception, (that of General Swift,) the only survivor of the celebrated expedition of Major Long to the Rocky Mountains. We owe this delay of the inevitable summons of the grim messenger principally to the fact that we were the youngest of a party numbering twenty-six. I was appointed as assistant naturalist and draughtsman of the expedition, and, among other duties, was directed by the letter of my instructions to give attention to the method employed by the natives in the preparation of the skins of animals killed for food or for their furs.

The material used for the preservation of the skins is principally the brains of the animal from which they were taken. While the skins are fresh, or in their green state, they are stretched on the ground, and scraped with an instrument of bone or stone, resembling an adze; the adhering portions of flesh are removed, and the surface is then plastered over with the brains, mixed in some cases with the liver, and on this is poured, from time to time, warm water in which the meat has been boiled. The whole is then suffered to dry, after which the skin is again subjected to the action of the brain and hot water, further stretched, and, while still wet, scraped and rubbed with stones until perfectly dry. It is further softened by rubbing and passing it backward and forward over a twisted sinew, stretched horizontally. The brain of an animal is sufficient to dress its skin; but, in some cases, a less quantity is sufficient for the purpose. I have myself used this process in the preparation of skins, but have found animal brains inferior, as a curing material, to a mixture of saltpeter and alum. The Indian, however, has no choice, and makes use of such materials as he can procure, and which, probably from accidental discovery and subsequent experience, he has found to produce the desired effect.

The marrow of bones of animals has generally been esteemed as a luxury, and among the Indians of this continent is held in high estimation, particularly that of the bones of the buffalo, the elk, the moose, and the deer. The round bones of these animals are roasted on the coals or before the fire, then split with a stone hatchet, and in some cases with a wedge driven in between the condyles when the bone has these ter-

minations. The marrow is then scooped out with a piece of wood cut into the form of a spoon, and eaten on the instant by the members of the party, seated around the camp fire. A feast of this kind can only be fully enjoyed after a successful hunt. When the marrow is collected in quantity for storing during the hunting season, which occurs usually twice a year, the bones of the larger animals are broken into small fragments and boiled in water until all the marrow which they contain and the grease which adheres to them are separated, and rise to the surface, when they are skimmed off and packed in bladders, or in the muscular coat of the stomach and in the large intestines, which have been previously prepared for this use. Not only is the marrow of the large bones of the limbs preserved in this manner, but also that of the vertebral column. The bones of this are comminuted by pounding them with a stone hammer, similar to those which are plowed up in the Eastern States.

REPORT OF AN EXPLORATION OF ANCIENT MOUNDS IN UNION COUNTY, KENTUCKY,

Made by the request and at the expense of the Smithsonian Institution.

BY SIDNEY S. LYON.

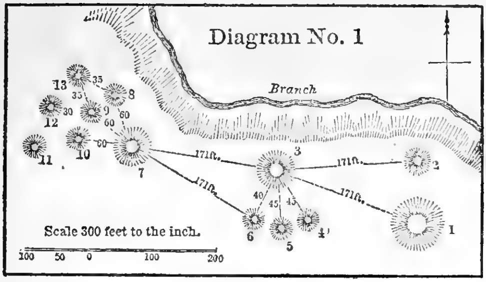
JEFFERSONVILLE, INDIANA, *July* 29, 1868.

I have made to the Institution the following shipments: First, from Shawneetown, one box containing casts of all that was left of the famous "Foot-print Rock," the last of this rude carving having been destroyed or removed since my examination in 1858. Second, four barrels of specimens from the Lindsay mounds, or that from which was taken the parcels sent by myself several years since to the Institution. These articles were taken from the land belonging to Leonard Roberson, but the property has since changed ownership. Third, three barrels and three boxes; the barrels contain articles from mounds 37 and 38, shown on diagram No. 6; box No. 2 contains articles from the Lindsay mound, and a few from other places; box No. 3, articles from McCoughely's mound, in the rear of Raleigh, Kentucky; box No. 4, some of the best articles from mounds 37 and 38.

The results of this exploration have been of less interest than I expected. I encountered unforeseen difficulties. The greatest trouble was to get and retain good laborers, and the utter impossibility of boarding them near the field of operations. During the last twenty-two days the men had to walk four miles to and from their work, with the thermometer at 95°. An expedition, to operate most efficiently, should be provided with tents and encamp near the work. The company should be organized before starting and not depend on assistance which may be procured in the country. There is a great field for investigation on both sides of the Ohio, near the mouth of the Wabash River. The people of the country have little or no exact information as to the number or location of the mounds. When a field is cleared inclosing a mound, and bones are ploughed up, the fact becomes known, but the existence of mounds in the woods or on the ridges is almost unknown; and as they are undoubtedly very numerous an explorer would find work enough to do.

I send you diagrams of some of the groups I have examined, with an account of their character, and of the facts obtained during the forty-two days of our exploration. I hope the results of my labors may prove satisfactory to the Institution, although they are not all I could have wished.

The diagrams of the groups of mounds are not deduced from exact surveys as to course or distance, the bearings having been taken by a common pocket-compass and the distance measured by stepping.



This group consists of three sub-groups. The one most eastwardly is composed of two mounds. No. 1 is 80 feet in diameter and 10 feet high; No. 2 is 40 feet in diameter and 4 feet high. The middle sub-group consists of four mounds 171 feet* distant from Nos. 1 and 2; Nos. 4, 5, and 6 are severally 45, 45, and 40 feet distant from No. 3, which is 60 feet diameter and 8 feet high; Nos. 4, 5, and 6 are 33 feet diameter; Nos. 4 and 5 are 3 feet high; No. 6 is $5\frac{1}{2}$ feet high.

The most westwardly sub-group consists of seven mounds. No. 7 is a large one, about 70 feet diameter and 10 feet high; Nos. 10 and 11 are 4 feet high; Nos. 8, 9, 12, and 13 are 3 feet high; Nos. 8, 9, and 10 are 60 feet from No. 7; Nos. 11, 12, and 13 are from 33 to 35 feet from the bases of Nos. 8, 9, and 10 severally.

This remarkable group of mounds is situated in Union County, Kentucky, about two miles from the ferry-landing opposite Shawneetown, and about half a mile south of the "foot-print rocks." Mounds Nos. 1, 3, 6, and 7 were opened near the center many years since by Dr. Gieger. I could not learn if anything had been taken from them. The appearance of disturbance left by the excavation of Dr. Gieger indicates that the openings made by him were not sufficient to develop the full contents of the mounds.

I opened mounds Nos. 2 and 4 by digging a ditch about 5 feet wide from the margin of the mounds to the middle of each, expanding the opening at the center to a circle of 8 feet. The ditch and center of the mounds were excavated to the original soil; nothing was found in either.

The mounds 2 and 4 were begun on the soil and composed of a loose sandy loam, probably obtained in the neighborhood.

Nos. 1, 3, and 7 are large mounds, the others are low and flat and have the appearance of the mounds which I consider as *common* burial mounds.

All the mounds of Diagram No. 1 are on a flat, low ridge, about 40 feet above high-water of the Ohio River.

This group of four mounds (Diagram No. 2) was visited with the intention of excavating No. 3, but it was not possible to get men to walk so far. My attention was called to this group of mounds by Mr. Richardson, of Uniontown, who had knowledge of the opening of mound No. 3 for the purpose of interring a

* The measurements above are from base to base of the mounds and not from center to center.

negro man, who desired to be buried there. In digging the grave, skeletons were discovered and also three or four earthen vessels. These mounds are on the lands of Mr. Burbank, about 1½ miles west of the group on Diagram No. 1. No examination was made of the country lying immediately between these groups.

The Lindsay mound.—This is an isolated mound, there being no other nearer than half a mile. It is situated on the low hills which form the margin of the flat lands on Buffalo Creek, a tributary of Cypress Creek, of the Ohio, about four miles in the rear of Raleigh, Union County, Kentucky. It terminates a low point of a low ridge and is about 33 feet in diameter. It was examined in 1854 and many skeletons discovered, with specimens of pottery; with three skulls. The latter were forwarded to the Smithsonian Institution at that time. This examination having revealed the character of the mound, I determined to explore it thoroughly. The work was begun on the west side (the lowest) and the whole examined by trenches from 4 to 6 feet deep.

On the west side bodies were found covered with six feet of earth, forming there about five separate layers. The bones of the lowest layer were so tender that they could not be removed, and deeper digging was not made. It is therefore not known whether the lowest bodies in this mound were reached. It would appear that the general plan of burial was to scrape the surface free from all vegetable matter, and deposit the body on its back, with the head turned to the left side. The bodies at the bottom of the heap, so far as could be ascertained by the examination, were buried without weapons, tools, or burial urns, (pots.) No traces of vegetable matter could be found in the fine siliceous earth with which these deeply-buried bodies were covered. To the depth of three feet from the surface, some of the bodies had with them burial urns. They were found near the bodies of infants and young persons, and it was with difficulty a single fragment of the bones could be procured by caving in the face of the digging. The bones of old and adult persons were well preserved in the siliceous loam, but very imperfectly in clay. Three or four tiers of skeletons, of later burials, were covered with clay. It is probable that as many as three hundred bodies, infant and adult, were buried in this mound. All the flints and other works of art found entire were packed in the four barrels and box No. 2 sent. The pressure of the roots of the trees growing upon and around the mound had broken many of the burial urns. Several of these, of unusual form, were sent without any attempt at restoration. No bodies were buried exactly in or near the center of the elevation, but they appear to have been arranged in a circle, head inward for the first layer, and extended toward the margin by an additional circle or more of bodies. Adults and children were buried together, the latter lying between the former. Toward the margin of this mound on the east side, there was some irregularity in the burials. Three bodies were found head outward, three or four lying nearly at right angles

to the radii of the circle. No urns were found with any of these irregular bodies. Some of them lay in clay were too tender for removal.

A poplar tree was felled ten years ago at the margin of this mound, of which the rings, counted at the time, indicated an age of two hundred and forty-nine years. A root of this tree, over one foot in diameter, ran nearly across the mound. At one point where this root was cut away were found four tiers of bodies under and two above it. Two or three excavations had been made long since into this mound, through one of which the large root passed, showing a greater antiquity than that of the tree. The colored earth showed, in one of these excavations in section, an inverted cone with irregular outline four and a half feet at the surface and one foot wide at the depth of five and a half feet. This hole or evidence of an excavation extended down to the earth of uniform color. At the bottom were found the skull of a female elk, two odd jaws of bears, and a small bundle of deer-bone awls. Three other of these ancient pits contained bodies. The direction of the heads was irregular, not conforming to the common method of burials. With one body flint weapons were found; this was at a depth of five and a half feet. The parcel of flints in box 2, the deer-horn tips, and the fragment of elk-horn were found with this body. The principal works of art obtained were the specimens of pottery.

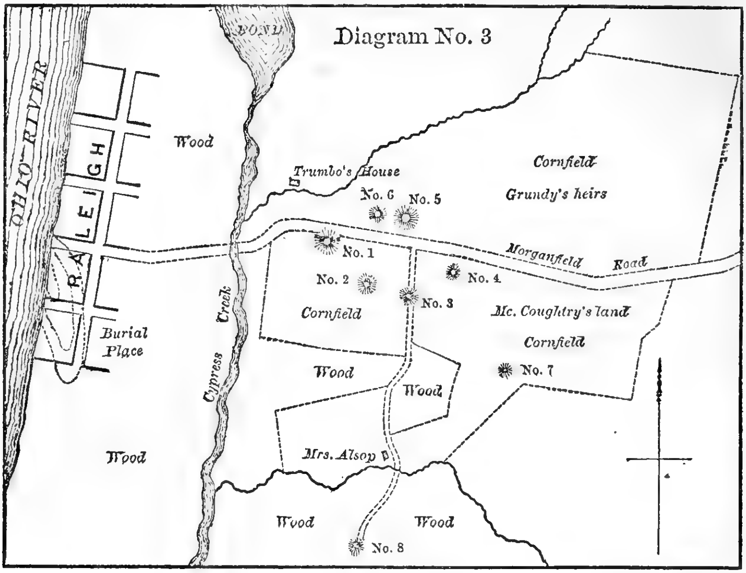
On the northeast side of the mound the original soil was reached. On the west side it was not met with at a depth of $6\frac{1}{2}$ feet. The entire mound was dug away except at the margin, and where large trees interfered with the work on the northwest side. The first burials either were made by those who had no works of art, or no superstition or usage requiring such articles to be buried with their dead. No bark or vegeable substance was used to cover and protect the bodies, or else they have entirely disappeared.

The character of the earth forming the whole mound, except at the northeast side, is such that it may be traced to a considerable excavation, distant one hundred and fifty yards toward the southwest. The mound was evidently formed by burials made on a cleanly-scraped surface, on which the body was laid, and then covered with the yellow sandy loam from the pit just alluded to.

The burials to the depth of three feet from the surface appear to have been made in the same form and manner as those below, and the addition of the burial vases distinctly marks either a change of art or superstition. The irregular burials are those made by excavation in the mound, and filling the hole over the bodies. A critical examination of these holes satisfied me that no sharp tool was used in making them. Sticks and the hands appear to have been the implements employed.

In the Lindsay mound are three kinds of burial: those without works of art; those with works of art bodies laid on the surface; and those of the deep excavations, which contain badly preserved bones, and

cut through the ancient surface. The graves dug were filled with mixed and discolored earth. Such a mound as the Lindsay mound I term a common burial-place, or a burial-place of the common people.



There are other mounds somewhat differing from the preceding and evidently for a different use. Of these, No. 1, Diagram No. 3, is an example. This mound is about 125 feet in diameter, and from 9 to 10 feet high. It was examined by digging a ditch 45 feet long, 6 feet wide, and 8 feet deep; beginning about 10 feet from the southeast side, curving a little toward the north to avoid a large tree, and at the middle bearing under in various directions to obtain any articles that might have been buried near the center of the structure. Here I found nothing. I learned after my work was done that many years ago this mound had been examined and some articles obtained at a center opening. Although I added nothing to the collection, I ascertained that this mound was of a different construction, and evidently for a very different purpose from that of the burial mounds.

The excavation exhibits a central nucleus of sand, about two feet high and twenty feet in diameter. This was built upon, preserving the rounded form, the layers of earth thicker in the center, and gradually becoming thinner toward the margin, until the work was completed. The earth over the sandy center appears to have been deposited in loads of about half a bushel each of the soil and subsoil of the surrounding fields, distinctly marked in sections into mottled layers; such a structure as would be made if the soil and subsoil were excavated from 15 to 18 inches deep around the mound. Near the margin of the mound was found a pit about three feet in diameter, extending into the subsoil about two feet, filled with alternate layers of earth and ashes. The ap-

pearance was such as would be presented if a pit were dug of the dimensions stated, a considerable amount of wood burned in it, after a long interval of time (leaves and earth having accumulated half a foot thick) a large fire again made and long continued, producing an inch thickness of ashes, the fire suffered to burn out and no coals left, thus adding successive layers of ashes and earth until the hole was full. The fires must have been repeated seven or eight times, lining the entire hole with ashes, and gradually filling the excavation.

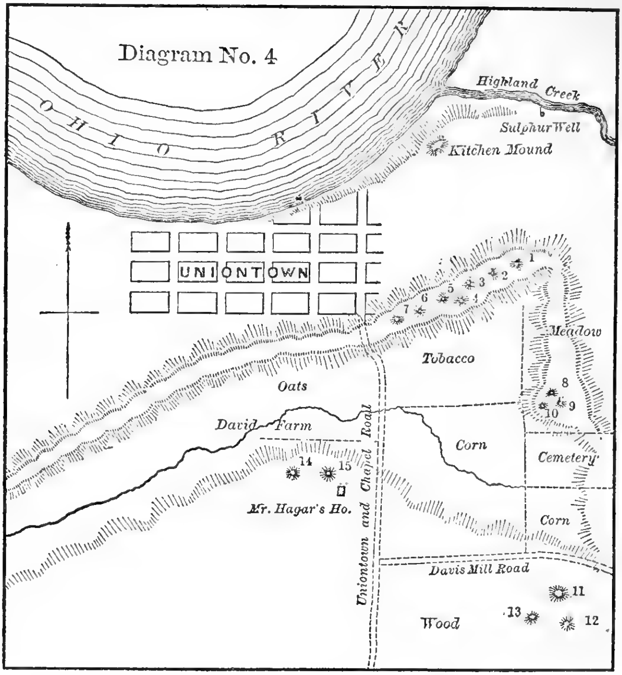
No. 8, Diagram 3, was next examined. This is a low mound, 45 feet in diameter, formed of sandy loam, very uniform in quality and color. Rounded pebbles of the same character and general appearance as those on the shore of the Ohio, one and a quarter mile distant, were found buried in groups of two, three, five, and seven. Attracted by this grouping of the pebbles a large amount of labor was bestowed on this mound. It had evidently not been made for a burial-place.

No. 3 appearing of the right form, and not being on cultivated land liable to be injured by the excavated materials, was more than half dug over by my party to a depth of three feet. It yielded broken pottery, rough fragments of flint, burnt surfaces from one to three feet deep, but nothing worth preserving.

By permission of the proprietor, and promised payment for the corn destroyed, I opened mound No. 4. This, like the Lindsay mound, proved to be a common burial-place. Pottery and broken pots strewed the ground. The top of the mound had been reduced by cultivation. Some of the bodies had been half cut away by the plow, and most of the burial vases broken. I dug this mound entirely over. The bones found were very tender. With one skeleton was a parcel of paint, a large double-pointed flint, and a small one; an arrow-head, a small piece of specular (?) iron ore from Missouri or Arkansas, and some small flints. The broken pot was a large one, placed near the shoulder on the left arm. Only a few of the burial urns escaped the plow, roots, frost, and the spades of my men. I sent in the box (marked McCoughtry mound on some of the parcels) every thing supposed to be of interest. My own experience teaches me that clay or tough, loamy soil is not as good a material to preserve the bones and pottery as the fine siliceous earth. (Loess of Dr. D. D. Owen. See Kentucky Reports.)

I next began operations on the first range of low hills immediately in the rear of Uniontown, nearly south of the mouth of Highland Creek, Diagram No 4. This group consists of seven mounds, three large and four small ones. Southeast lies a group of three, and south of these another group of three; Nos. 14 and 15 are about fifty yards apart, 40 feet diameter, 8 to 10 feet high, about the size of Nos. 3, 4, and 5. Nos. 1, 2, 6, 7, 8, 9, 10, 11, 12, and 13 are low mounds, varying in size from 25 feet to 60 feet diameter, and from 3 to 4 feet in height. Near the mouth of Highland Creek is a Kitchen mound. There are a few Indian burials along the line of the river bank. These are covered with

clay, evidently subjected to the action of fire. Mound No. 1 was examined by a ditch from east to west, 4 feet deep, 30 feet long. This ditch cut out the center of the mound and reached the subsoil. Some



small fragments of pottery and a few irregular chips of flint, and the character of the material forming the structure, were the only evidences of its artificial nature.

Mound No. 5, one of the three large ones of this group, we dug away about one-third. On the southeast side several skeletons were found, at a depth of about 3½ feet; two or three skulls without bodies, and some parcels of bones, evidently dismembered before burial. All these interments appear to have been secondary. This mound is composed of materials differing in character, and resembles mound No. 1, (Diagram No. 3.)

Mounds Nos. 9, 10, and 11, on examination were found to be of clay, and therefore, as already explained, a detailed investigation was not made. Mound 14 had been dug into for an ice-house vault. Mr. J. W. Hagar, son of the party who built the ice-house, and who aided in the excavation, made the following statement in reference to this mound:

"At a depth of 6½ feet, near the center, we found the body of a man, buried in a sitting position. Near his head, on the west side, was found a variety of articles—a pointed flint-arrow or spear-head, from 10 to 12 inches long, 3½ to 4 inches wide, beautifully made; it was not a double-pointed flint, but had a groove for fastening; three circular stones, half an inch thick, an inch and a half in diameter, concave on both sides, a

hole through the center, the margin grooved like a pulley, (we called these pulley stones,) with about five small perforations from the center of the margin of the pulley, in the direction of radii, to the opening in the center; an article five inches long made of copper nearly in the form of an awl, the large end or handle very much oxidized, (probably had a wooden handle;) a flat stone with holes; an earthen pot broken, contents about one gallon; a thin piece of copper one-sixteenth of an inch thick, irregularly round, covered with some woven fabric not unlike fine linen. The diameter of the disk of copper was about three inches."

In box No. 2 is a copper disk, which was found in a low mound with two other pieces similar in form and size, by Mr. McKenny, who states that the three disks appeared to be the ends and middle of a "spool," which when found had on it what appeared to be the remains of a fine twine

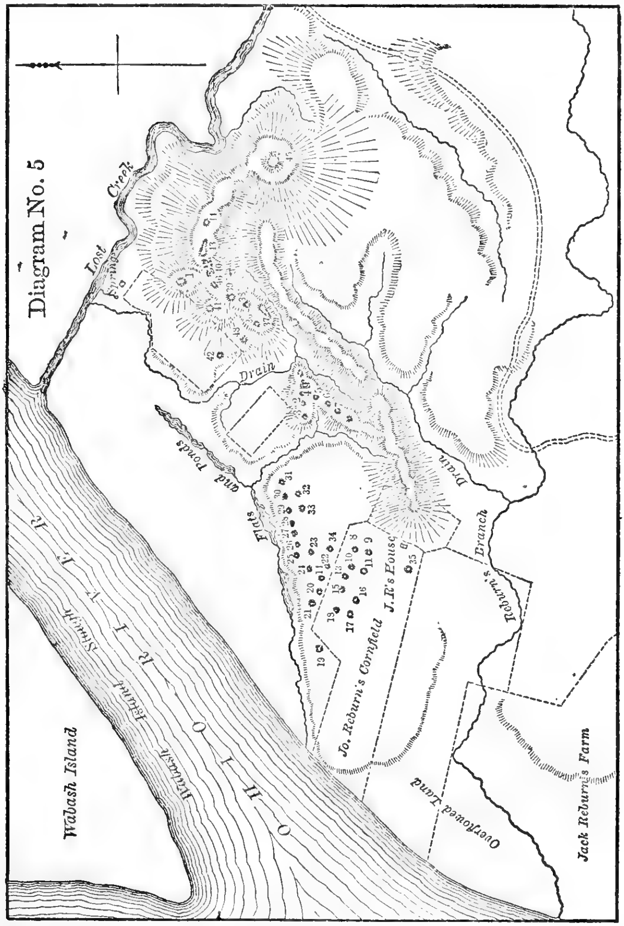


Diagram No. 5

or coarse thread. The mound from which this copper article was taken was a low one, 10 feet in diameter. Being in a field, it was soon plowed

down to its foundation, which was a circular pavement of stones. These being in the way, they were dug out and removed. On the north side of the pavement was found a heap of ashes, and lying across the pavement, nearly in the center of it, the bones of an adult. No other work of art than the disks was found. The earth removed from the center was about 18 inches deep.

The mounds near Uniontown not proving of sufficient interest for my present purpose, I proceeded to examine a locality near the mouth of Lost Creek, opposite Wabash Island, Union County, Kentucky. Diagram No. 5 presents a rough sketch of this remarkable collection of groups of mounds. When I first examined this series of mounds I noted them roughly on a sketch. As my knowledge of their number increased, and my book being too small to map them on a scale, I proceeded to measure the distances between the several mounds, and to estimate their height. I began on the 8th mound and made the following measurements and estimates, from center to center of mounds:

Copy of notes.

8. Mound in field, 5½ feet high, 90 feet diameter; distance between 8 and 10, 354 feet; distance from 10 to 12, 54 feet.

12. Diameter 33 feet.

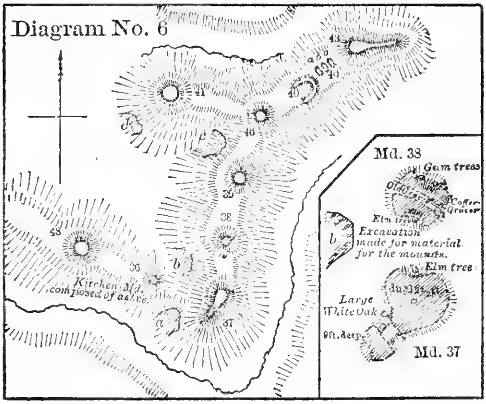
In the following notes the distances given is that between two mounds, as for example between 10 and 13:

10 and 13, distance, 54 feet; 10 is 3 feet high.
12 and 13, distance, 84 feet; height of 12 and 13, 4 feet; 13 is 40 feet diameter.
13 and 15, distance, 120 feet.
13 and 16, distance, 159 feet; 15, 42 feet diameter; 16 is 54 feet diameter.
16 and 17, distance, 51 feet; diameter of 17, 36 feet.
17 and 18, distance, 81 feet; diameter of 18, 33 feet.
18 and 19, distance, 165 feet.
13 and 14, distance, 80 feet; diameter of 14, 40 feet; 18 is 3 feet high.
14 and 20, distance, 54 feet; diameter of 20 is 74 feet; height of 20, 7 feet.
20 and 21, distance, 71 feet; diameter of 21, 33 feet; 3 feet high.
14 and 22, distance, 75 feet; diameter of 22, 48 feet; 3 feet high.
22 and 23, distance, 114 feet; diameter of 23, 72 feet; 3 feet high.
23 and 24, distance, 69 feet; diameter of 24, 66 feet; 8 feet high.
24 and 25, distance, 75 feet.
25 and 26, distance, 75 feet; mounds 25, 26, and 27 are 3 feet high; diameter of mound 26, 36 feet.
26 and 27, distance, 100 feet; diameter of 27 and 28, 40 feet.
28 and 29, distance, 50 feet; diameter 33 feet; height, 3 feet.
29 and 30, distance, 63 feet; diameter 33 feet; height, 3 feet.
30 and 31, distance, 75 feet; diameter 33 feet; height, 3 feet.
31 and 32, distance, 45 feet; diameter 20 feet; height, 2 feet.
32 and 33, distance, 75 feet; diameter 33 feet; height, 5 feet.
33 and 34, distance, 100 feet; diameter 33 feet; height, 5 feet.
35 from 8, distance, 800 feet; diameter 80 feet; height, 6 feet.

Nos. 2, 3, 4, 5, 6, 7, &c., are quite close together on the back of a sharp, narrow ridge. No. 4 is an oblong, rectangular mound, about 30 feet long, 12 feet wide on top, 8 to 10 feet high. Mounds 5, 6, and 7 have been used for burial places within the last few months. Mounds

22, 23, and 24 were partially examined. They did not prove to be common burial-places, and were abandoned for the present. These mounds are formed of sand, different from that found in the hills near by and that used for the covering of bodies in the common burial-places. The material used appears to have been taken from the drifts of fine sand washed by the Ohio River in to the overflowed land.

The operations were then carried on in mounds 37, 38, and 46. I was attracted to mound 37 by stones standing near the center of it. This is the only mound examined by me in which stones were used to form any portion. No. 37 is an oblong or pear-shaped mound, the largest part being 65 feet diameter; the neck, 42 feet long. The greatest length 107 feet; greatest width, 65 feet. The scale of Diagram No. 5 is too small to exhibit the form or arrangement of the group to which 37 belongs. It will be better seen on Diagram No. 6.



Mound No. 37 (Diagram No. 6) was opened on the northwest side, at a point which appeared to be the margin of the artificial part of the hill. The discoloration from the leaves and decomposed vegetable matter penetrated the earth about three feet deep. At the depth of two feet bodies were encountered. The earth was well thrown back and an opening 14 feet long and 5 feet deep was made, giving a face on the side of the ditch toward the mound 14 feet long by 5 feet deep. The bottom of the ditch appeared to be the subsoil of the country, a stiff clay. By digging into this clay it was found to be very stiff, and full of a whitish mold not unlike that found within the skulls, and at the bottom of some of the burial urns or pots. During the progress of the work this clay was found to cover all the circular part of the mound removed. (See Diagram No. 6, mound 37.) In contact with the clay $5\frac{1}{2}$ feet deep the bones were very tender. When near the center of the mound I had an opening made into the supposed subsoil, and found it to be a coat of stiff moldy clay covering bodies buried one above another to the depth of $12\frac{1}{2}$ feet. At the base of the clay, 6 feet deep, was found an irregular pavement of limestone, evidently obtained from an outcrop of the "Carthage limestone" occurring half a mile to the north. The same limestone forms the bed of the Ohio River between the Kentucky shore and the head of Wabash Island, one mile distant.

The margin of the mound at 6 feet below the summit and on a line with the pavement was composed principally of small pieces of the same

rock. The pieces composing the pavement varied in size from 20 to 150 pounds weight. Many of the bodies found at the base of the clay appeared to have been covered by slabs of the stone forming the pavement set up slanting toward the body with the ends of opposite stones resting against each other, thus roofing the body in.

The bodies beneath the clay did not appear to have been buried in the order generally observed in the mounds heretofore examined. Beneath the clay bed, to the depth of 6 feet, the bodies were evidently buried by covering, after having been laid upon a cleaned surface, with the sandy earth obtained from some of the banks, marked *a*, *b*, *c*. (Diagram No. 6.)

A large excavation was made below the clay and pavement and many bodies removed; the bones were quite tender. No works of art were found. The hole was filled up and the work carried across the mound to the depth of the mouldy clay.

I was particularly interested in the fact that in this mound there was an absence of all works of art in the deep burials, and less regularity and system in the manner of arranging the bodies than that observed in the later burials or the urn-burying tribes. As in the Lindsay mound the deeper-placed bodies did not invariably lie on the left side, and the head was sometimes on one side, sometimes on the other, sometimes thrown forward or backward. The mouth was frequently open, retaining a horrible expression. No fragment of pottery or flint was found under the clay layer in mound 37. Two or three of the skulls of the deep burials will be found in barrel No. 5 shipped from Uniontown, Kentucky.

The burials above the clay layer of this mound conform generally to the plan of those of the Lindsay mound: heads inward, lying on the left side, &c. There do not appear to have been so many pots buried as there were bodies. The use of the burial urns seems to have been more frequent at the burials in the Lindsay and McCoughtery mounds than in this one. Some of the last bodies placed in this mound with an urn were very slightly covered. Two bodies which were found with urns were covered from the head to the hips with rough stone similar in arrangement to those bodies alluded to which were found under the clay layer of this mound. A few vases were found entire, but the greater number were broken. Some appeared to have been broken before they were placed with the dead body about to be covered.

With some of the bodies, about 3 feet below the surface, there occurred a parcel of small, long, round bones. In one of these parcels was a needle made of bone and an ornament made of the shell of an unio, also a pair of unio shell drops. The hurry and discomfort of the work forbid a very careful examination of the articles, or an attempt to sketch any of them. A single double-pointed flint was the only article of stone found in the mound, and this not in any apparent connection with a body. It appeared to have been dropped upon

the top of the mound, and was found not deeper than six inches below the surface. In working southwardly, toward the white-oak, in mound 37, the end of a discolored line of earth, 3 feet wide, was encountered. This was carefully followed 5 feet deep to a skeleton, the head lying toward the north, feet south. This was evidently an interment made in an excavated pit. Extreme caution was used in removing this body. The head was found entire. Near the head, in the position of the ears, were found the two copper bells packed in box No. 3.

In making the original excavation for the reception of this body, at least three bodies, or parts of bodies, had been removed, and this body placed as deep as the third or fourth tier of layers, the head resting on the layer of moldy clay, so frequently referred to. There were three or four other burials made by excavating in this mound, but as nothing worthy of note was found with them they require no special description. The bones removed by digging the graves referred to appear to have been carelessly thrown into the grave over the newly buried body, but never in immediate contact with it.

A considerable excavation was made into the elongated neck of this mound. Urn burials extended down about 5 feet, regularly disposed. The digging was carried 9 feet in depth, and great irregularity was observed. At the depth of 5½ feet the body of a youth was found. The skull and long bones were sent in barrel 6. This body may be known by the base of a deer's horn packed with the skull. The whole horn was buried just above the face, the head slightly elevated, directed outward, and toward the falling land or slope. Parcels of bones disconnected were found buried in this part of the mound, in excavations which cut through former burials; heads disconnected from bodies, loose bones, &c. With one of the regular covered burials, about 3 feet deep, were found some ornaments made of panther's (?) teeth. Two or three feet distant from this body was found a parcel, in discolored earth, containing parts of a jaw with feline teeth and some pieces of vertebra of an unknown animal. The number of relics obtained was very small, when the amount of work done in the examination is considered. A considerable number of long bones were preserved and packed in barrel No. 5, also one entire vertebral column. The material among these bodies is the same as that in the Lindsay mound, but generally the bones are not as well preserved.

There are several mounds in this group of grander proportions than No. 37, which would doubtless prove of great interest if thoroughly examined—300 or 400 cubic yards carefully removed from some of these mounds would probably yield many valuable and interesting results.

In the group of mounds 2, 3, 4, 5, 6, and 7, (Diagram 5,) the mounds 5 and 6 are the site of a recent burial-place.

Mound No. 36 (Diagram No. 6) was examined by a ditch 5 feet wide and 18 feet long, extending from the south side northwardly beyond

the center. It proved to have been a kitchen, being composed principally of ashes of unio shells, broken pottery, bones of animals, &c. A small ax or skin-dressing chisel was found at the surface. The fragments of pottery appeared to be parts of vessels, differing in form from those found in the mounds. The vessels were larger, thicker, and generally parts of shallow dishes. The fragments of one vessel, resembling these, was found in mound 38, and one in the neck of 37. These fragments are among the articles from these mounds sent to the Smithsonian.

Mound 38 (Diagram No. 6) was thoroughly examined. It was a low mound, about 4 feet high and 45 feet in diameter. Figure 38 (*a*) (Diagram 6) shows the amount of surface uncovered in this mound.

It appeared to have been completely covered by two layers of the bodies of the vase-burying people. On the southeast side were found three of the stone burial-places, of a later period than the vase burials, some of the vases and bodies with which they were buried having been removed to give place for these later structures. A trench from 4 to 6 feet wide had been worked over through the center of the mound, from the stone boxes toward the northwest, disturbing the bodies.

Sometime this later digging cut a previously buried body in twain, leaving the head and feet in place, the more recent burial having been made in a line nearly at right angles with the body partially removed. This disturbance rendered the work very difficult. While tracing one body longitudinally another was encountered lying at right angles, either above, below, or cutting through the body being traced.

In the undisturbed part of mound 38 the bodies observed the arrangement referred to at the Lindsay mound.

It was in the disturbed part of mound No. 38 that the two pipes were found. I was careful that the decomposed portions of the stone on one of the pipes should be preserved, for it may possibly give some hint as to the length of time these articles have been buried. A small conical-shaped article was found with the body, and also the black stone with holes through it. I have seen this kind of an instrument used by the Pah-Utes, of Southeastern Nevada, for giving uniform size to their bow-strings.

A few burial urns with seven ears were found in No. 38. I do not recollect that any of this form were found in any other mound. The bones in mound 38 were not so firm as those found in other mounds. Many bodies were disinterred of which bones were sufficiently firm to pack up. Barrel No. 6 contains the most perfect skulls from mound 38. A considerable number of long bones from this mound will be found in barrel No. 7. I omitted to mention an article found in mound 37, circular in form, apparently formed of bone.

With the exception of the copper bells all the articles found and forwarded to the Institution are of the rudest form and evidently the product of a primitive people. The fact of the bells having been found in

a dug burial-place indicates a later burial and a race of different habits. I have no hypothesis as to the time these mounds were made. They do not appear to have been constructed by a warlike race. Only two bodies, of about 1,000, that I have encountered seem to have been buried with anything like arms.

To one who has made a study of the mound-builders, the groups of mounds (Diagram 5) would offer great inducements for investigation.

I have observed some remarkable facts in reference to the mounds, but they are too few in number and too disconnected to form a good foundation for a true theory of the life and condition of the mound-builders of this district. A careful examination of the cranica by a competent person will perhaps throw some light on the intellectual condition of this people.

This report is hastily written from my notes made in the field. It may serve, however, as part of the basis of a regular work, to be prepared by some properly qualified person who may have the results of this investigation before him. In my examination of the mounds I was compelled to pack away the articles collected as fast as they came to hand, the sun affecting the bones injuriously.

To any one who may continue this work I would recommend the months of September and October, with tents, and all such conveniences as will enable the party to make full notes. Let the laborers be hired for the trip, and informed as to what they are to do and how they are to do it. Many crania and burial-vases in good condition when reached, were broken by the haste, awkwardness, or carelessness of the men. With proper preparation and careful, industrious laborers, important results may be expected.

Probably many of the articles, especially the bones sent, will be thrown out as useless. Some of the bones were packed up and forwarded to show how much they were decayed. Many long bones were sent to determine the stature of these people. It was a common remark during the work that the bones were of very large size. I think the men were generally under size—not so large as the men of this age.

A considerable number of ribs were taken from the Lindsay mound under the impression that they indicated bodies less round than the present races. This question I am not able to answer; but I have, on much reflection, concluded that the peculiar form of these ribs is in a great measure due to the pressure of the earth on the bodies.

In unpacking the bones sent I would recommend that each parcel as it is opened be washed and dipped in weak glue, when dry, that each bone, intended for preservation, receive a thin coat of the best copal varnish. This was the treatment I gave to the bones sent to the Institution in 1856, taken from the Robinson mound.

SKETCH OF ANCIENT EARTHWORKS ON THE UPPER MISSOURI.

By A. Barrandt, C. E., *of Sioux City.*

The archæological remains of the Upper Missouri, from the mouth of the Yellowstone, in a southeasterly direction as far down as Bonhomme Island below Fort Randall, exhibit a progressive change of structure and outline from the most simple to the most complicated. During my stay in that region, 1869–'70, I had occasion to visit several of those ancient fortifications. Among the most important and well preserved is one existing about nine miles south-southeast of the Missouri and within half a mile of Clark's Creek, Dakota. The main work is in the form of a parallelogram, three hundred and forty feet long, one hundred and ninety feet wide, and twenty and twenty-five feet high; the walls are, on an average, seven feet thick at the summit. There are two openings, one facing the west, twenty-four feet wide, and the other facing south, only nine feet wide. The space inside is now full of cottonwood and ash trees. Several large blocks of sandstone, roughly hewn, were found, but the walls and a ruined portion of what appeared to be the remains of a smaller inclosure, were of calcined clay, changed by burning into a brick color. Following the banks of the creek for half a mile, we came to the remains of a wall of about five feet in width and in some places attaining the height of from three to five feet. We traced the wall for about four hundred yards; it runs for about one hundred and fifty yards from east to west, then turning at right angles from north to south, the end of which reaches the edge of a deep and precipitous ravine, beyond which we could not find any traces of ruins.

About two hundred and fifty miles up the Bighorn River we found also another large mass of ruins, where was probably the site of a large mound city, but none are now existing; they have all crumbled away, and from a large oak tree that we felled, I found that they must have occupied this spot at least six hundred years ago, as the tree grew on the remains of what had been probably the largest mound. We found that these mounds had, for the most part, been constructed of turf and adobe or sun-dried bricks of inferior manufacture, which accounts for their decay.

Another curious spot that I visited was what the Indians of the present time call Matou-tipee, (Bear-house.) It is a large mound constructed of calcinated clay, which by burning was changed into a brick color. It is situated near Grand River on a high elevation of land; it is encircled by the remains of a wall; one portion running from east to west and then down a hollow; turning at a right angle it runs from north to

south, the ends reaching the banks of the creek. Within the area of these remains of gigantic walls we found several small mounds of from twenty to forty feet in circumference, and from ten to fifteen feet high.

Further up the Yellowstone I found the remains of an ancient city of mounds. It is situated about one hundred and forty miles from the mouth of that river, on a bluff of about one hundred and eighty feet in height. It seems to have been regularly laid out. The streets are regular, and the mounds equidistant from each other. In the southeast quarter of this city, on the widest of the streets, is one of colossal dimensions, sixty-three feet in diameter at the summit, and twenty-seven feet high.

We could not find any opening in this mound, but succeeded by digging into several of the smaller ones to gather remains of some sun-dried pottery; and in one we also found several arrow-heads of stone, fragments of flint, &c. I counted these mounds, and found eighty-seven in good state of preservation, and about sixty-three in ruins. I am satisfied that the remains of the elongated mounds, which are found always on the outskirts of a city, were designed and used for fortifications, though I have not been able to determine if there were any ditches around them. Again, on the banks of the Moreau river, a few miles from its mouth, we discovered another of the mound cities, containing about two hundred mounds, and a number of the elongated ones, which form a regular line of outworks, each wing reaching the bank of the river. Again, about two and a half miles further back to the north upon an elevation of the ground there is a group of the largest mounds I have ever seen. They are built very near together, and are perfect in their form. There are no ditches at their base, and they are wanting in other appearance of fortifications. Yet I believe them to have been used as forts, and that they were placed here to guard the approaches to the town from this direction.

There is still another group of mounds located on the banks of the Great Cheyenne; these resemble those last described—not so large, but more in number.

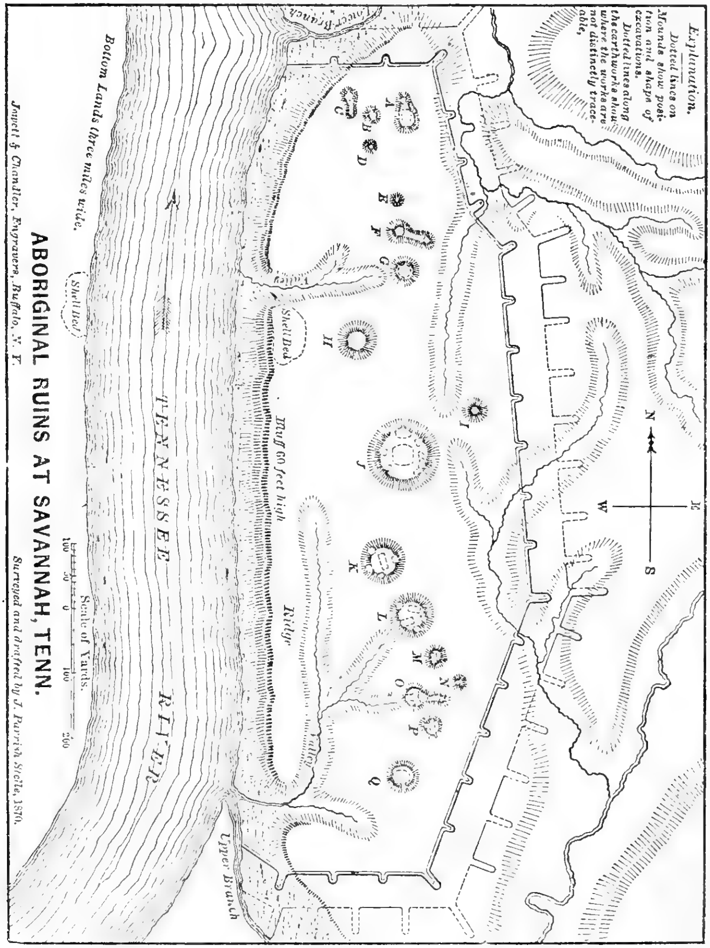
On Bonhomme Island there are also remains of fortifications, which are described in Lewis and Clarke's journal of their expedition up the Missouri, 1804–'5–'6.

This hasty sketch of some of the ancient remains in the Missouri Valley, though the result of the observations of two years, is principally drawn from the hasty entries in a diary; therefore no pretensions are made to minute exactness. As, however, the preservation of a record of the sites of the ancient remains, and every fact connected with it, is important to the student of archæology, this sketch, brief and imperfect as it is, may afford some data of interest in regard to the character of the race of men who once thickly peopled this country.

ACCOUNT OF ABORIGINAL RUINS AT SAVANNAH, TENNESSEE.

By J. Parish Stelle.

These ruins occupy high rolling ground, on the east side of Tennessee River, immediately on the west edge of the town of Savannah, Tennessee. North and south they measure, from outer earth-works to outer earth-works, thirteen hundred and eighty-five yards, and east and west, five hundred and fifty yards. The inner line of earth-works is distinctly traceable, and consists of an embankment thrown up inside from a deep trench, twelve or fourteen feet in width. At every eighty yards there is a redoubt, each one extending outward twenty yards, excepting those at the angles, which project thirty.



The outer line of earth-works appears to have been much lighter. At some points it is still visible, while at others, especially on cultivated grounds, it has entirely disappeared. In the diagram the obliterated parts are represented by dotted lines, and the distinct portions by continuous lines. The outer works are fifty-five yards from the inner, and parallel with them. They also have regular redoubts eighty yards apart; but the redoubts are longer than those of the inner works, measuring forty yards along the line, and fifty-five yards at the angles. The two lines are so arranged that the redoubts of one generally alternate with those of the other.

The earth in which these trenches have been dug is a tough red clay, intermixed with gravel, exceedingly hard to excavate. In fact, the entire elevation upon which the ruins lie is composed of the same material, down almost to low-water mark of the river, where a deposit of limestone begins.

The relative position of the mounds have been located on the diagram by careful measurement.

Mound A: Ten feet high, forty yards east and west, and sixty yards north and south. I made a large excavation in the highest part of it, going down in shape somewhat as shown by the dotted line. At the depth of a foot and a half we came upon a human skeleton, lying on its back, with the head to the south. The bones were so decayed that but few could be taken out. At the left side of the head was a vase, containing the remains of a shell. The root of a tree had grown against and broken the vase, but I took out all that could be found. At the right of the skeleton, about where the hand should have been, if the arm lay at the side, were found three flint implements—knives, I suppose—and a small polished stone that had probably been used for painting purposes. Nothing more was found in this mound. We dug down to the solid earth in two places, as shown by the dotted lines. The mound was composed of a soft alluvial soil, evidently brought from the river bottom, about two hundred yards distant, and down a steep hill.

Mound B: A small one, into which we made a large opening in the center, and at one foot down obtained a stone implement, which was the only article found. The composition of this mound was the same as that of A.

Mound C: Double mound, four feet high. Into this we went down to solid earth in two places, but found nothing, except some bits of charcoal and other evidences of there having been fire at several points. It was made up of alluvial soil, the same as A.

Mound D: Has a house upon it, and therefore could not be opened.

Mound E: Small mound in the garden, with a large tree upon it. I did not open it.

Mound F: Double mound, seventy yards long, forty yards wide at widest point, and twelve feet high. We dug down to solid ground by two large excavations started at the highest points. Within three feet

of the surface, in the excavation, fragments of pottery utensils were found. Nothing further was discovered. These mounds, unlike the preceding, were composed of the tough clay and gravel of the ridge upon which they stood. A depression near at hand showed where the material had been obtained.

Mound G: Forty-five yards in diameter at base, and twelve feet high. Two large white-oak (*Quercus alba*) trees were upon it. In one, which had been cut down, two hundred and fifteen rings were counted, making it two hundred and fifteen years old. We dug a large circular excavation in the center on the top. The earth at the surface gave indications of having been intensely heated. At two feet down we came upon a human skeleton lying on its back, with the hands at the sides, and the head toward the east; the bones badly decayed. At three and a half feet we found another skeleton, lying precisely the same as the first, and immediately under it. At five feet we came to loose stones lying upon one another, and rounded up mound-shaped, which we removed, to the amount of several tons, when the solid earth was reached, and a skeleton was found lying exactly as the others, but further east, the feet of this one being immediately under the heads of the other two. The stones seemed to have been thrown directly upon the body; consequently most of the bones were more or less broken. The skull was crushed entirely flat. At the left side of the head were found three copper relics, lying just as I have tied them together. The string still to be seen in one of them is made, I think, from the bark of papaw, (*Asimina triloba*, Dunal,) a circumstance worthy of note, as it proves that material to be almost imperishable. Modern Indians used it extensively for strings and ropes, and I can recollect when our southern and western people did the same. It was prepared by peeling the bark from the trees when the sap was up, and sinking it under water, to remain several weeks, to "rot," as it was called. When taken out the inner separated from the outer bark, and split up into very thin sheets. It was these sheets that were used, and after having gone through this process they were much stronger than the entire bark was before. I send you a slip of "rotted papaw bark." Immediately upon the breast of the third skeleton was found the fragments of a shell ornament. Nothing further was discovered in "G," though we made careful and extensive search. The composition of the mound, aside from the stones already mentioned, was light surface soil, which seemed to have been scraped up from the high lands.

Mound H: A large mound, ten feet high. It is under cultivation, and therefore cannot be opened before autumn.

Mound I: Has a house upon it, and therefore no examination could be made.

Mound J: Is the largest mound in the group. It is over one hundred yards in diameter at the base, thirty feet high, and perfectly level on the top. We rigged a windlass, and sunk an eight-foot shaft in the

center, down to the solid earth, but found nothing, except now and then a broken flint or fragment of pottery. We then dug in the sides, permitting the earth to fall into the shaft, until we had a large excavation, in the shape represented on the diagram, but still found nothing. We next made excavations twelve feet deep, at various points, but discovered nothing in any of them, except in one. Here, within a few inches of the surface, we came upon broken fragments of brick, or burned earth, exhibiting some kind of molded work. They were in considerable quantities, and looked as if they might originally have been hollow columns. If solid columns, the fragments would certainly have been larger; the specimens sent are of average size. Immediately under these, about one foot below the surface, was what might be styled a tile floor, perfectly level and smooth. We removed the earth, and found it to be somewhat crescent-shaped, covering a space of forty-four feet one way, and sixteen the other. How much larger it had been we could not learn, for roots had grown into it and broken it up. The tiling, if such it can be called, was about an inch thick, and seemed to have been made by spreading tempered clay smoothly upon a leveled space of earth and then hardening by means of fire built on top of it. There were no seams to indicate that it had been made otherwise and laid down in sections. Nothing else was found, except some charcoal around the edges.

Like F, this large central mound was composed of tough clay and gravel, making it very hard to dig. Within a short distance were three great depressions, from which the earth of which it was formed had evidently been taken.

Mound K: A low mound, eighty yards in diameter at the base. We opened it in various places, as shown in the drawing. Six feet in the center brought us to the bottom, eighteen inches of which was composed of a soft, black earth, in which were found bones, deer horns, shells, fragments of pottery, &c. In this deposit we also found two stone implements, probably used for pounding corn, opening shell-fish, or something of the kind.

Mound L is similar to K in every respect. In addition to the usual *melange* of black earth, bones, shells, &c., we found one pounder and two pieces of red stone, which, I suppose, had been used for painting. We also found one flint knife. Persons not familiar with such relics might mistake these knives for arrow or spear heads, from which they differ in not having notches worked in the large end for the purpose of attaching them to a shaft.

Mound M: Thirty yards across at base, and five feet high. At two feet down we came upon a fossil shell and a beautifully-finished little stone; I call it a paint mortar. There was no sign of bones, which leads to the supposition that these articles were simply buried there for safe-keeping. At four feet down we found a large and splendid stone implement. It was lying near one side of the mound, and appeared to

have been lost there, as there were no visible marks of anything further. Nothing more was found in this mound. The composition, light soil, as usual, shows that it had been gathered from the surface.

Mound N: Fifteen yards across, and three feet high. Two feet down we found a broken stone implement, which was the only article obtained. The composition of the mound was the same as M.

Mound O: A double mound, forty by seventy yards at base of largest end, and eight feet high. We excavated at three points, and found two to be of no interest whatever. The third one, at the large end of the mound, proved otherwise. We started down through red and crumbly earth, indicating that it had been exposed to high heat. The deeper we went the stronger the indications of fire became, until finally, when three feet below the surface, we came to a bed of charcoal, or rather what proved to be a charred log lying horizontally. We opened the mound thoroughly, and found that it had three furnaces passing in at the base of the lower side, (the mound is on inclined ground,) and running parallel, about six feet apart, almost entirely through to the base of the higher side; that is, ranging upward through the mound at the angle of the surface of the solid ground upon which the mound stood. They had been formed by first digging trenches into the earth, two feet wide and eighteen inches deep. Over these, rude arches had been thrown, formed of irregular masses of tempered clay, probably sun-dried. Some of these masses we took out entire. They are about as large as a man could handle conveniently, and having been immediately in contact with the fire, are burned very hard.

In the spaces formed between these furnace trenches, and near the center of the mound, were found two small piles of human bones, (one pile in each space,) which seemed to have been thrown together without regard to regularity. I do not think there could have been more than about two skeletons in each pile. They were completely charred by the heat from the furnaces, and consequently were very tender to handle. On drying out they became much harder. From the three main furnace trenches went up a large number of small flues, eight or ten inches in diameter, whose walls had also been formed of tempered clay, and were now burned very hard. At some points they rose directly toward the surface of the mound, while from others they wound and twisted about through it in various directions, all skillfully planned with a view to conveying the heat to all parts of the pile.

Running through the mound horizontally, at different elevations, were large logs still retaining their entire shape, but completely charred. We traced one from end to end, eighteen inches in diameter and twenty-two feet long. The ends showed that they had been burned off to make the piece the desired length, and their great irregularity of outline led me to think that the operation had been performed while the log was yet green, and retained its sap. The burning had evidently been forced by placing dry pieces of wood across the log and keeping

them carefully "chunked up," and the irregularities were due to the different positions of the cross-pieces; the log, in consequence of being green, having immediately ceased to burn when there was no direct contact.

In addition to these charred logs there were a number of upright posts, also charred, which seemed to have been placed in position as the earth had been filled in, to prevent too great a pressure upon the flues. Some of them were more than a foot in diameter and five or six feet long. Their ends presented the same irregular outline as the horizontal pieces. I found one piece of split timber four feet long, eight inches wide, and two inches thick. Its ends showed that it had been broken to its existing length by main force, for, although a solid coal, the splinters were yet perfect.

I saw nothing about any of these timbers that indicated their having been worked by other means than fire, and if there had been anything I would certainly have noticed it, for they were entire, just as they had been placed in the mound, merely large, solid coals. The coal was in as good a state of preservation as if burned but yesterday, as you will see by the specimen sent. Two of our blacksmiths have examined these specimens. Both agree that one kind is chestnut, (*Castanea vesca*, Linn.,) but differ with reference to the other—one claiming that it is poplar, (*Liriodendron tulipifera*, Linn.,) while the other pronounces it our yellow pine, (*Pinus rigida*, Miller.) The two former trees grow abundantly about the locality of the ruins, but the pine has not grown nearer than four or five miles since the country has been known to white people.

Every part of the large end of this mound, from base to top, had been affected by the heat from the furnaces and flues. In fact, it was one huge brick, hard burned near the base, and softer toward the top. The earth seemed to have been thrown up loose; none of it had been tempered except that forming the arch of the furnaces and the walls of the flues. There were no fragments of pottery, or dross, or cinders, or anything else upon which a hypothesis could be based touching the object for which the mound had been used. Ashes in the furnaces, bones, burned earth, and charred timbers, as already mentioned, were the only things found after a most careful and exhaustive examination.

Mound P: This mound, about fifteen yards across and four feet high, was opened by curiosity-seekers two years ago. Report says they found nine copper spools like those taken from G, a copper wedge, and a stone paint mortar, as I call it in default of a better name. After diligent inquiry among the people interested in the digging, I have succeeded in obtaining the "wedge," the mortar, and part of one of the spools. The discoloration in the concaves of the mortar is due to something put into it since it was found—indelible ink, (nitrate of silver,) I think. The markings around the edge were the same when found.

The parties who did the digging assure me that they saw no bones, but I think they must have overlooked them, for on opening the mound

more thoroughly I found fragments of a human skull, but no other bones. These lay near the edge of their opening; hence I conclude that they must have taken the skeleton out. I also found, lower down, three fragments of stone implements. The composition of the mound was surface soil, as usual.

Mound Q: Twenty yards across at base, and nine feet high. At eighteen inches down we came upon a bed of coals and burned earth, evidently where a large fire had been. At three feet, in what appeared to be a deposit of ashes, we found a copper relic; at four feet, lying alone in the yellow earth, a stone implement; at four and a half feet, what seems to be a copper plate attached to a fragment of matting; at six feet, a second stone implement like the first; at eight feet, lying immediately together, three pieces of lead ore; and at nine feet, on the solid earth, a small string of copper beads.

There were no bones or other things in this mound indicating that it had been used as a burial-place. All the articles found, except the copper wheel, lay immediately in the yellow earth, and there were no discolorations in the adjoining soil, which must have been the case had perishable articles been buried with them.

I think you will find the beads are held together by the same imperishable material to be seen in the copper relics found in G.

SHELL BEDS.

There are two extensive shell beds in connection with these ruins, one on each side of the river. That on the eastern side has been under cultivation for years, and lying immediately upon the surface it is not in so good a condition as it would otherwise have been. It covers about half an acre of ground, and is some eighteen inches in thickness. I explored it pretty thoroughly before this season's crop was put in, and in the collection marked "R" you will find the result, together with some of the shells composing the mass.

The bed on the west side of the river was entirely undisturbed until I examined it. It covers a little less than half an acre, is about two feet in thickness, and lies three feet below the surface; that is, the overflows of the river have made a sedimentary deposit upon the shell bed three feet thick. Taking into consideration that this river seldom overflows oftener than once in a year, and sometimes but once in several years, that its waters are not then as muddy as most other rivers at such times, and that being a mountain stream it soon subsides, we can form at least *some* idea of the age of this shell bed. In addition to this, I may say there is now growing upon it a burr-oak tree, (*Quercus macrocarpa*, Michx.,) fully six feet in diameter.

I explored this bed carefully, and you will find an assortment of what I obtained in the collection marked "S," together with specimens of the

shells. The broken pottery was in great abundance, and seems to have been broken vessels thrown away with the shells and other refuse. The same shell-fish are now to be met with in the river, but they do not seem to be in great abundance, judging from what are found along the shore. It is possible that they are more plentiful at the bottom of the river, however, and that these "old-time people" had some way of dredging them up.

The river is wearing the bank away where the bed crops out; consequently I had a very good opportunity of noting its position. It lies perfectly horizontal, and, for some distance up and down the river on either side of it, the caving bank is literally dotted with places where fires seem to have burned for a long time; the earth is burned hard and to redness, and ashes and coals are there. In digging out the places I found several with three stones in the center still occupying triangular positions, as if arranged for the purpose of supporting cooking utensils above the fire. These fires were generally on a level with the bottom of the shell bed.

ACCOUNT OF ABORIGINAL RUINS ON THE WILLIAMS FARM, IN HARDIN COUNTY, TENNESSEE, TWO MILES BELOW SAVANNAH, TENNESSEE.

By J. Parish Stelle.

These ruins occupy a set of ridges running toward the bottom lands of the Tennessee River, about two miles below Savannah. The fronts of the ridges terminate in steep bluffs rising fifty feet above the level of the bottom. Along the foot of the bluffs there is a series of springs, spreading and forming swampy lands, and through these lands, also at the foot of the bluffs, runs a line of earthworks, made precisely on the plan of the earthworks in the Savannah ruins, with the exception that there is but one line traceable instead of two. It seems to have been located in the swampy grounds where the springs came out, with a view to having the ditch always full of water, which must have been its condition. The redoubts are about eighty yards apart. Most of the work is traceable; the points at which it is not clearly so I have indicated on the diagram by dotted lines.

No other line of earthworks save this at the foot of the bluffs is to be seen; hence we must infer that the defenses on other sides of the town were stockades, or something of the kind. The regular line of mounds back (A, P, V, W,) would lead to the conclusion that there had been other defenses, and that these mounds were erected for the purpose of overlooking them.

All the mounds of the group were carefully opened; the markings on the diagram show the shape and position of the excavations made.

A.—This is a round-shaped mound, twenty yards across and five feet high in the center. Upon its side is a dead white oak, *(Quercus alba,)* over three feet in diameter. Went to the bottom in the center, but found nothing. Composition yellow clay without gravel, showing that the material had been taken from the surface of the ridge, as gravel occurs a short distance beneath.

B.—Ten yards across and four feet high in center. Same character as A. Cut entirely through it, but found nothing.

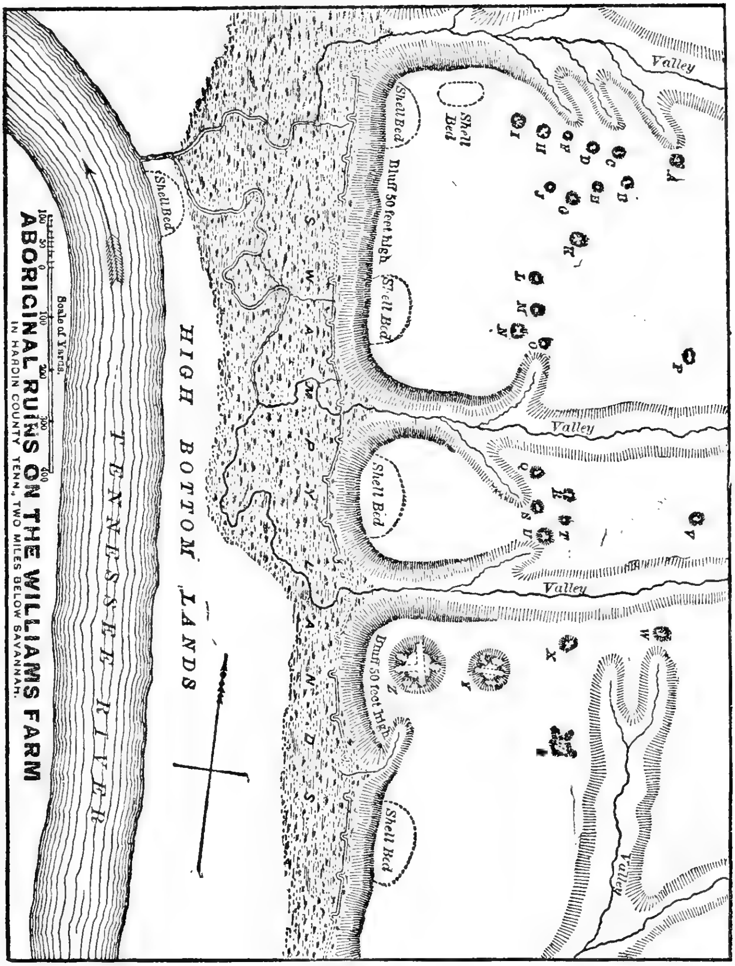
C.—Ten yards across and four feet high in center. Same character as B; opened it with same result.

D.—About same size, and precisely same character as C. Opened it, but found nothing.

E.—Ten yards across and six feet high. At eighteen inches down we came upon a human skeleton lying with its head toward the southeast. The bones were very badly decayed. There were a few shells with the bones. Nothing more was found. Upon the side of this mound there is a white oak stump over three feet in diameter.

F.—Five yards across and two feet high. Contained nothing.

G.—Fifteen yards across and four feet high. White oak tree over two feet in diameter growing upon it. At two feet down came upon a few fragments of decayed bones, so far decayed that we could make nothing of them.



H.—Twelve yards across and three feet high. On removing the surface, we found the mound to be nothing more nor less than a great shell-heap. Gave it a thorough turning, but found nothing save such things as are usually met with in these shell beds.

I.—Ten yards across and three feet high. Another mound composed partially of shells, though not entirely, as was the case with H. The shells were intermingled with yellow clay. At one foot down found a stone implement—probably a plow or hoe. You will observe that the large end of the implement is much worn, the probable result of working in the earth. There was nothing more.

J.—Ten yards wide and three feet high. Contained nothing.

K.—Twenty yards across and six feet high. Contained nothing.

L.—Ten yards across and two feet high. Contained nothing.

M.—Ten yards across and two feet high. At the bottom found a small stone implement lying alone in the yellow earth, apparently lost there when the mound was being made. There was nothing more.

N.—Twenty-five yards across and eight feet high. At two feet down came upon shells and fragments of pottery in considerable abundance. At three feet down, fragments of charcoal were to be seen, and the earth had a red appearance, indicating that it had been intensely heated. At six feet down we found an imperfect stone implement. There was nothing of further interest.

O.—Ten yards wide and three feet high. Contained nothing of interest.

P.—Twenty yards wide and five feet high. Contained nothing.

Q.—Eighteen yards wide and three feet high. A few scattering shells were found, but nothing of additional interest.

R.—Fifteen yards across and four feet high. Found one large arrow or spear-head, but nothing further.

S.—Twenty yards across and six feet high. Contained nothing.

T.—Ten yards across and two feet high. Nothing of interest.

U.—Twenty-five yards across and six feet high. A few small flint implements were found scattered here and there, as if lost at the time of building. Nothing more.

V.—Twenty yards wide and five feet high. Contained nothing.

W.—Twenty-two yards wide and six feet high. There were some traces of bones a few inches below the surface, but they were so much decayed that nothing could be made of them.

X.—Twenty-three yards wide and five feet high. Three feet down there was a deposit of black matter, looking as if some perishable substance, as a log of wood, had decayed. There was no sign of bones or anything else of interest.

Y.—Sixty yards across and seven feet high. Composed of black alluvial soil, evidently brought up the bluff from the river bottom. Examined it carefully, but found nothing.

Z.—One hundred yards across and ten feet high. Composed of black soil from the river bottom, the same as Y. Found traces of bones, evidently human, immediately on the solid earth, but the character of the soil making up the mound had caused them to decay so badly that but little could be made of them. There was nothing further of interest.

&.—Thirty yards across and twelve feet high. This mound has three arms running out from it, as shown in the diagram. They were evidently for the purpose of affording an easy ascent to the summit—the sides were, probably, too steep to be ascended with ease. Three feet down we came upon some badly decayed human bones, and with them some black substance which seems to have been matting. At seven feet

we found fragments of charcoal and red burned earth one foot thick, and four or five feet in diameter. At nine feet we found another stone implement, evidently used in working the earth. It has been broken, and on that account may possibly have been thrown away by the workmen engaged on the mound. There was nothing further worthy of note.

CHARACTER OF THE MOUNDS.

All the mounds of this group, with the exception of Y and Z, are composed of yellow clay, evidently taken from the surface of the ridges; and all, with the exception of &, are rounded on top and reasonably regular in outline. In general character, they seem to differ somewhat from the Savannah group, for none of them appear to have been places of deposit; in fact, I do not think there is a burial mound in the association. I am of the opinion that the few bones taken out are not those of the mound builders, but that they are the remains of more recent Indians, buried in the mounds by mere chance, or because their elevation above the common level gave them attractions as burial places.

The arrangement of this "Williams Farm" group has quite strongly impressed me with the belief that the mounds were made for two special purposes—one set, as A, P, V, W, and perhaps others, to stand as watchtowers, from which to overlook the defenses, and the other set, as A, C, F, O, S, U, W, X, to act as the lamp-posts of the town; that is, erected for illuminating purposes. I am led to this latter conclusion by their situation at the heads of the valleys. Fires kindled upon them even now, (and they must have been much taller originally,) would light every foot of valley making up into the town site. Add to these a few that might be selected upon the interior of the ridges, and the illumination of the entire site might be made complete. I found the same arrangement in the Savannah group. In fact, I have found it so in all the groups that I have visited.

SHELL BEDS.

There are a number of shell beds in connection with these ruins, but since they do not differ in any particular from the shell beds of the Savannah group, I have thought it best not to go into any particular exploration of them, or to trouble you with specimens.

FOSSIL WOOD.

In the same box with this I send you some specimens of fossil wood, taken from "Chalk Bluffs" on Tennessee River, in Hardin County, Tennessee. The "Bluffs" are caving banks, about three hundred feet high, washed at the base by the river.

I. The piece marked thus will explain itself. It is a sample of what I wrote you about as being part wood and part stone.

II. Fragments broken from the trunk of a tree six feet in diameter. Eight feet of what appears to be the butt end of this specimen is exposed, the remainder (no one knows how much) runs into the bluff.

III. Broken from a specimen seven feet long and four feet in diameter.

IV. Bark. Is washed out of the bluff in considerable quantities.

V. Specimens broken from the end of a log three feet in diameter, sticking squarely out of the bluff, embedded in the center of a seven-foot stratum of yellow sandstone. Bounding the stratum above and below are thick bands of iron ore.

VI. Sample of the yellow sandstone mentioned above.

VII. Sample of the deposit in which most of the fossils are found.

VIII. Specimens picked up at random about the bluffs.

TERRESTRIAL PHYSICS.

THE EARTHQUAKE IN PERU, AUGUST 13, 1868.

[*Extract from letters of John V. Campbell, superintendent of the Arica and Tacua Railroad.*]

TACUA, *November*, 1868.

The sight of Arica would fill with dismay any one who had known the place before. The destruction has been *complete*, and more need not be said, were it not that the ruins and signs of the great devastation that meet one on all sides make the aspect of the place so painful that people who once see it are afraid to look on it again. The lower part of the town is a heap of ruins, except where passages have been cleared to serve as streets, while in the upper part, beyond the reach of the tidal wave, many walls and parts of houses are still standing, but so cracked and shattered as to be quite uninhabitable, and they evidently show that, even without the aid of the sea, Arica was a mass of ruins after the heavy shock of the earthquake. Further back on the pampa, going toward Arapa, the people have built their wooden sheds in great numbers and with much regularity. It is said this will be the future site of the town.

In the part of the town that was washed by the sea the confusion of the ruins is indescribable, and the effect of the waves is bewildering. Alongside the mole is the stationary engine-boiler of the railway, also the remains of the two locomotive-tenders; up in the market-place is another tender, one of the boilers of the flour-mill, and one of the iron girders of Mr. Hegan's turn-table, all large pieces of iron weighing many tons, that have been carried by the force of the waves more than seven hundred yards. Facing Eusert's house, or rather the site where it stood, is one of the locomotives; farther on, facing Nugent's house, is another; and a few yards farther, the third, all in the sea, broken and completely worthless. The strength of the wave is, however, more apparent at San José, where the piers of the bridge have been cut off, on a level with the bed of the river, and carried in large compact blocks of masonry intact, four, five, and six hundred yards on to the highest ground behind. The tubular girders have been carried a similar distance, and many broken.

The bed of San José River has been filled up about four feet, while our embankment on each side has been washed down, and the temporary track we have built passes over the bed of the river with a culvert of only three feet. This of course the floods will carry away in winter, and how we shall ever manage to construct a permanent bridge I cannot yet

conceive. From San José to near the side track at Chacalluta, fully four miles, the railway track has been torn up and obliterated, the large sand-banks at Chiucoro have disappeared, and an open, level beach remains. The vessel Wateree is on the pampa five hundred yards inland, and about eighty from the highest ground; the America lies in the same line, about two hundred yards nearer the sea; while between them are the shattered remains of the Chañarcillo.

The waves approached nearer the hills than I ever could have thought possible, and the pampa for miles is strewn with wreck. The beach all along is covered with large stones, mixed up with sea-weeds, pieces of wood, of furniture, of machinery, and of boats and vessels; the mixture, which also includes rags, and abundance of papers, custom-house documents, etc., is, however, quite beyond any attempt at description.

Very few people can give a clear account of the catastrophe. Almost all appear to have been paralyzed with fear, and certainly they had good cause. Nugent is almost the only one who appears to have been collected and to have watched the progress of events. He says that when the sea receded, the anchorage of the steamers, which was in seven fathoms (forty-two feet) water, remained dry; that all the vessels were dragged seaward except the Chañarcillo and A. Riviere, which remained aground, and high and dry at their anchorage. Many minutes elapsed, during which the sea appeared to be gathering itself up, until at last it came like an enormous dark green wall, and swallowed up everything it could reach. The wave came over the top of the custom house, which will give some idea of its altitude.

The line to which it reached is forty-five feet nine inches above high-water level, which, added to the forty-two feet that it had receded, will give a wave nearly ninety feet in height. The current was very strong, the log of the Wateree says sixteen miles, and appears to have been circular like a whirlpool. The vessels could do nothing, and were carried about like chips. The A. Riviere was never seen again, but fragments of her wreck were washed ashore. The Chañarcillo, a much stronger vessel, came on shore completely smashed; and from the fact of her having five or six turns of her cables around her hull, we surmise that she must have turned over as many times before her anchor parted.

The loss of life so far ascertained is about five hundred and fifty, between the town and the bay. There were some singular escapes. John Williams's wife and children were carried in and out by the waves, of which there were eleven in all, a number of times, and were finally deposited on the high ground. Vacarro, who, having a broken leg, was placed by his friends in a large launch, was carried in and out every time, and was left at last among the ruins of the church of San Francisco. Eusert's horse at the mill was carried off by the waves, and two days afterward was found unhurt on the little island in the middle of the Sisera.

Matters in Arica are still in a bad way, as you may judge for your-

self, when I mention that the best-housed man in Arica is Ausdell, who is living in the remains of a first-class railway-car. I stay with him when in Arica.

Tacua had a marvelous escape. Only a few very old houses, these principally at the corners of the streets, where they had no support from other walls, came down. Of course every building suffered; but beyond plaster and paper falling down, and cracks at all the joints, I do not find much damage in any of our property. The dwelling-house stood well, and I have now increased confidence in its strength—a consolation, you may be sure, as we have seldom less than four to six earthquakes daily.

* * * * * * *

TACUA, *September* 15, 1869.

Months have appeared years since I last wrote you, so horrid have been the times through which I have passed, and yet I have to be grateful that I and my family are yet alive. I allude to the dreadful visitation of yellow fever, which now, thank God, has passed away.

It commenced in Arica in November, and up to 31st March, 1869, the official records alone show one thousand nine hundred and fifty-nine burials, but the real mortality was over two thousand five hundred. Of our contract-men in the station and workshop seventeen out of twenty died. In July, 1868, I shipped at Liverpool a blacksmith, John Parry, with his wife and three children, and I was in Arica when they reached their destination. First a child died, then the mother, the father followed, and I was taking measures to send home the two orphans, when they died also. The family was thus wiped out completely, and there were many other similar cases.

In Tacua the fever broke out with the suddenness of an explosion and swept to their last rest over three thousand three hundred souls. The mortality would have been much greater, but the people fled to the hills and in that way escaped contagion. Among my wife's relatives we lost, counting grown-up people only, her aunt, and two of her sons, and two cousins. I lost four clerks, and among them our book-keeper and cashier, men we cannot readily replace.

Our situation through March, April, and May was awful; we were expecting death at every moment and continually sorrowing for the loss of one friend after another. At times there were no bakers and no bread, no butchers and no shops. All the apothecaries died and their places had to be taken by amateurs. The carts were insufficient to carry the dead, and three relays of cartmen died in succession. The cemeteries were filled to repletion, and then the bodies were thrown into trenches. We are now walling round these trenches, and they take over seven thousand feet of wall to inclose them.

I have recalled to my memory a time that now appears to me a horrid dream, and I had better turn to a more agreeable subject. You

will now comprehend my long silence, as since the 30th May I have been busy at reorganization, drilling new hands, and pulling up heavy arrears of work.

As you ask me for particulars of earthquakes, I will tell you the result of my long-continued observations. Their course here is invariably from the mountain range to the sea—in this district from east by north to west by south. Walls built north and south—that is, across the course of movement—are those that suffer most. Many have fallen and all are more or less injured. Walls built east and west suffer little if at all, except occasionally when they are at the corner of the street, and then only a few of the last adobes fall.

The movements appear to have the greatest intensity or rather effect in sand. The walls of houses built on sand when they do not fall, as most frequently they do, are left in a crumbled condition, crashed and shattered in every direction. It is clear that the earthquake movement imparts a variety of movements to sand. I think, too, the force that causes the movements acts in the line of least resistance, or tries to liberate itself where it finds its work easiest.

You remember the "big cut" on the A. and T. line and the conglomerate that you so often anathematized. That conglomerate, however, resists earthquakes, and I attribute the preservation of Tacna on the 13th August, 1868, to the town being built on it. Not a stone falls in the big cut, and I have a hole in the yard of my house fifty-one feet deep, all through this formation, with an old wall two feet from its edge, that I was sure would have fallen in, but to my great surprise everything remained sound and intact. This conglomerate is, as you know, very tough and must offer immense resistance to the earthquake force.

Our rock here is all trachyte tuffa, a few stages only removed from pumice-stone, and offers little or no resistance to the earthquake shocks. Houses built on it fall easily.

The earthquake waves are low and only measure a few inches in height. The damage they cause appears to me more owing to duration than to altitude of the movement. The earthquake of the 24th ultimo lasted ninety seconds and left things standing; while a duration of five minutes would have brought them down. The effect of this last earthquake on vessels at sea you will find in the Valparaiso papers of last mail in the case of the ship Payta. The water appeared to run away from the vessel's sides, and the people in her feared being submerged. She was fifty-seven miles south of Arica, in a direct line east and west with Islaya, now, as then, in a violent state of eruption, and must have been caught in the very center of the movement.

The effects of an earthquake on a train in motion are worth mentioning. On the 13th of August, 1868, the Presidente (our very first and last engine) took up the train, (regulation load one hundred and twenty tons, cars included, but exclusive of locomotive and tender twenty-two and one-half tons,) and was going at about sixteen miles per hour when

it suddenly stopped with a smart shock. Mr. Ansdell, who was a passenger, thought something had given way on the engine, while Braithwaite, the driver, thought the stoppage was caused from behind. The train, however, would not move, so the steam was shut off and both got down to examine matters. They could hardly stand on the ground, and at once perceived the true state of the case.

Earthquakes are very frequent yet, and the people are in a state of panic, a German astronomer, Falb, having predicted our total destruction on the 30th September or 1st October; while an Englishman, Saxeby, defers the event until the 5th of October. The people are deserting Arica, and the authorities are making us bring up the customhouse to Tacua. On the railway we can barely keep our work going. In Tacua two-thirds of the population are sleeping in tents. I never before witnessed such a fright. People refuse to transact business until after the 5th of October, or when purchases are made delivery is stipulated for after that date.

Several shocks, and two very severe ones on the 20th and 24th of August, have enforced the German's predictions, and it is becoming heresy to argue against him. The Cordillera is to be the shore of the Pacific.

The anniversary of the 13th August was a great day in Arica. There were masses and religious processions to prevent a repetition of the great cataclysm, but the people were very anxious, and passed the day on the hill-tops, relieving themselves at intervals by prayer and flying visits to the taverns. All, however, passed off well.

THE ELECTRO-MAGNETIC SEISMOGRAPH.

By Prof. Palmieri, of the University of Naples.

[*Translated by B. O. Duncan, esq., United States consul, and furnished to the Smithsonian Institution by the Department of State.*]

In all the instruments invented up to the present time for registering the movement of the earth's surface, the force itself of the motion of the earth has been charged with the labor necessary for preserving the trace of the shocks; and this is the reason why slight oscillations of the soil could not be registered. In the seismograph, which I am about to describe, it is the electric current which performs the labor, and, therefore, it is possible to have a registering apparatus capable of the greatest precision even for the slightest shocks. It is also possible by means of this apparatus to perceive the register of many vibrations of the earth which would otherwise escape observation.

Suspended above a small iron cup containing mercury is a fine brass wire coiled into the form of a cork-screw, of about fourteen or fifteen turns.

The diameter of the wire is about one millimeter, and that of the spiral twenty or twenty-five millimeters. This spiral is supported at its upper extremity by a thin elastic spring, and can be elevated or lowered by means of a screw. The lower extremity of the spiral is terminated in a cone of copper, pointed with platinum, which is kept at a very minute distance from the mercury contained in an iron cup, which is placed on a column of wood or marble. The distance from the point of platinum to the mercury may be varied at pleasure, but once fixed upon it remains invariable, in spite of any changes of temperature, owing to a very simple system of compensation; the rod which sustains the spiral being of a metal which expands upward, with an increase of temperature, as much as the spiral is lengthened downward. The iron cup and the spiral are in communication with the poles of one of Daniell's galvanic batteries of two *couples.*

If the surface of the earth is agitated by a vertical shock, even scarcely perceptible, the point of platinum will touch the mercury below it, and will complete the current of the battery. Then two electro-magnets, which are in the same circuit, will attract their armatures or keepers, and the first will stop the running of a clock, which marks the days of the month, the hours, the minutes, and the half-seconds; and will thus register the exact moment of the commencement of the shock. At the very instant the clock stops it gives a signal of alarm by means of a bell. The second electro-magnet in drawing its armature sets free the pendulum of a second clock, which had been stopped out of the vertical line, and this clock in running causes a band of paper to move at the rate of three meters an hour. At the same time the armature of the second electro-magnet presses a pencil against the paper as it passes over a little pulley, and causes it to trace a series of dots on the paper, corresponding in length to the duration of the shock; the shock having ceased, the paper will continue its movement unwinding from one cylinder and winding up on another; and if another shock occurs, the pencil will register it as before by another series of dots, and thus continue; so that the intervals remaining unmarked will indicate the hours of repose, and the parts marked the duration of the oscillations.

To other spirals, formed with different numbers of coils, are suspended small magnets, under which are placed some iron filings, which adhere to the magnets when they oscillate vertically; and thus they preserve the trace of vertical shocks. One of these spirals causes a light needle to move on a graduated arc, and thus measures the extent of the oscillations.

Four glass tubes, each bent at both extremities at right angles, having thus two vertical branches, united at the middle of the base of the horizontal portion, serve to indicate the horizontal shocks; one of the two vertical branches has a diameter at least double the other, but is shorter. These four tubes are arranged in the direction of the four *cardinal points.* As they are all alike and act in the same way, it will

be sufficient to notice one of them. A certain quantity of mercury having been poured into this tube, a wire of iron or platinum is put in the branch with the greater diameter, and another platinum wire is placed at a very small distance from the surface of the mercury contained in the branch with the smaller diameter.

On the surface of the mercury contained in the branch with the smaller diameter is placed a floating piece of iron suspended by a fine silk thread, which passes over an ivory pulley, with a counter-weight so regulated that if the floating piece is raised by the mercury it remains separated from it, (at the point to which it had been raised;) and as the axis of the pulley has attached to it a long and light needle, it is evident that this needle will deviate when the floating piece rises, and that remaining fixed, it will indicate upon the arc of the graduated circle the number of degrees it has traced. If there be a horizontal shock in the direction of one of these tubes of mercury, the mercury will be agitated in the two vertical branches, but, undergoing more perceptible oscillations in the branch with the smaller diameter, it will raise the floating piece of iron, and will cause the needle to deviate in a corresponding manner. But at the same instant the mercury will touch the point of the platinum wire, and the electric current, which will thus have passage, will excite the two electro-magnets before mentioned, and will act in the same manner as already explained for vertical shocks. The deviation of the needle will indicate the direction of the shock; and if the shock is not in the exact direction of the tubes, its real direction will be indicated by two needles.

By the aid of the electric current, shocks may be registered which would otherwise escape notice on account of their extreme slightness, for the trembling of the surface has no resistance to overcome, provided that the points of platinum are placed very near the surface of the mercury. I have added some auxiliary apparatus for shocks a little more violent. For instance, I have placed at the base of the column the mercury-apparatus of Coulier or of Cacciatore. At the extremity of the metallic wire I have suspended a metal globe, which, in oscillating, moves the light horizontal tubes by which it is surrounded.

One clock is intended to make known with the precision of a half-second the beginning of the shock; but to know the hour in which the shock occurs, the other clock will suffice; for the length of the paper unrolled by the wheel, and the hours marked by the needle, will indicate sufficiently the time. This apparatus registers all the shocks that take place, indicating the duration of each and the time that elapses between them; but it cannot give the nature and intensity of each of them. By it we can know if all the shocks were vertical, and also their maximum intensity. We can likewise know if all were horizontal, and if they had the same direction, or if the direction was different. We can also know if there was one shock of one kind, and another of a different kind. This seemed to me sufficient for registering the movements (trem-

blings) of the surface, which are frequent on Vesuvius, but which are very rarely observed. The apparatus being visited at least three or four times daily, at the ordinary hours of observation, and the alarm-clock announcing the moment when the shocks occur, the instrument may always be put back into its normal condition. This is the reason why I have not thought it necessary to add other parts, which would render it more complicated.

But for violent earthquakes, which compel the leaving of the house, and which render the visiting of the apparatus dangerous, one can, by the action itself of the violent shocks, register the character, the duration, and intensity of each of them, with the aid of an auxiliary apparatus that I have long ago prepared in my mind, but which I have not yet had executed. My principal object was to discover the slight movements of the surface which hitherto escaped us entirely. The seismograph above described has not only given me the surest indications of approaching eruptions of Vesuvius, but it indicates also the violent earthquakes which occur in Italy and the entire basin of the Mediterranean, even the eruptions of Etna and of Santorin.

In localities exposed to violent earthquakes this apparatus should be placed on a solid foundation of masonry, constructed immediately on the surface, and protected by a covering of wood capable of resisting the shocks.

ON THE DISTRIBUTION OF FOREST-TREES IN MONTANA, IDAHO, AND WASHINGTON.

By W. W. Johnson.

In accordance with the promise made, I submit the following views of the distribution of forest-trees over that portion of the Northwest comprising the Territories of Montana, Idaho, and Washington, or more particularly the region extending from the forty-fifth to the fiftieth parallel of north latitude and from the one hundred and tenth meridian to the Pacific Ocean. This part of our continent is traversed by three systems of mountains, the Rocky, Bitter Root, and Cascade Ranges. The mountain system of the two first named occupy a space of about two hundred miles in width, or from about the one hundred and twelfth to the one hundred and seventeenth meridian, while the latter lies in the vicinity of the one hundred and twentieth meridian, and their general direction is north and south; these are approximate locations, and are stated as limits of description. The traveler through the Rocky and Bitter Root Mountains would be unable to tell where he left the one or entered the other. The valleys of the main water-courses are broad and timberless, while the banks of every stream are fringed with a belt of cottonwood, with willows, alders, and a small birch undergrowth. While the mountain spurs and ridges which form the boundaries of these

valleys, and in which these streams take their rise, are timbered more or less heavily with the several varieties of firs and pines, the loftier ranges, say from six thousand to eight thousand feet in altitude, are clothed with a thick growth of tall black pines, which are from three to ten inches in diameter, of from thirty to fifty feet in height, while the lower ranges and spurs have firs and pines from saplings up to six and nine feet in diameter, the tallest trees being probably from one hundred to two hundred feet in height. Geological formation has something to do with the growth and variety of timber, the granitic soils being apparently preferred by the pines, while the firs are the most abundant on the limestones and old red sandstones. Upon nearing the limits of vegetation upon the many peaks whose summits are seldom destitute of snow, the stunted pine appears to be the only tree which struggles there to maintain its foothold.

West of the Bitter Root River, which washes the eastern base of the formidable range of mountains called in one locality the Bitter Root and in another the Cœur d'Alene Mountains, the character of the country changes. The streams which meander in sinuous courses through the cañons, gorges, defiles, and ravines of this region, which has a width of from seventy to one hundred and forty miles, are confined to narrow beds between mountain spurs, and the entire face of the country is covered with a forest which has forbidden, until lately, even the hardy and adventurous miner from exploring its fastnesses, and determining the heads and courses of its draining streams. After leaving the western base of this mountain-bed we enter the great plain of the Columbia, where no trees are seen, except along the water-courses, as on the eastern side of the mountains, over a vast plain which presents to the eye the appearance of a rolling ocean tossed by contending billows. Crossing this plain, up nearly to the summits of the Cascade Mountains, a distance of about one hundred and fifty miles, we again enter into the timber, which stretches thence in an almost unbroken forest to the Pacific, where the trees of pines and firs assume gigantic proportions, and have given to Washington Territory the reputation of affording the best spar and ship timber in the United States, if not in the world. To the north, when you enter into the region of the Upper Columbia and its tributaries, which rise in the damp lake country of the British possessions, as far as my experience goes, the fiftieth parallel, the country yields as fine a growth of timber as in the mountain regions to the south of it, similar in character, but wider in its extent. This country is devoid of any extensive prairies, and is but sparsely inhabited, and has been imperfectly explored.

Having thus given the outlines of the distribution of the trees over the tract set forth, I would suggest the theory which presents itself to my observation, as accounting for the treeless valleys, prairies, and plains which form so large a part of our great West. When I first entered that country, nearly eleven years ago, I was much struck by the absence of

rains in summer on these plains. Showers would come up as they do in the eastern part of the United States, but seemed to be drawn and swept along the sides of the mountains, where they expended their moisture, giving only to us in the prairies the comfort of their shadows. I noticed this in a residence of some five years in the Walla-Walla Valley, on the southern boundary of the great plain of the Columbia, as well as in the many valleys of Montana. Living, as I have for several summers, under canvas, and my business calling my attention to the clouds and the trees, my experience there corroborates my observation in Walla-Walla, as showing that the showers of summer are of much more frequent occurrence along the mountain-sides, and are always of longer duration among the timbered peaks and foot-hills than in the lower and treeless portions of the country. The trees grow always along the streams, where there is a constant supply of water, although the soil may not differ in any material respect from that in the immediate vicinity, which, being dry and unnourished by rains, afford no nutriment to the seeds of the cottonwood, the pine, or the fir. Not only the absence of rains in summer, but the absence of snows in winter, are a preventive to the growth of forests. Thus, we see these valleys are seldom visited by snows of any depth, from twelve to twenty-four inches being the limits of deposit in ordinary winters, and frequently the fall over their surfaces does not reach a depth of over five or six inches, while in the elevated lands of the mountains in the timber, snows of from three to seven feet are of almost universal occurrence every winter, and in the northern latitudes referred to, while the altitude is not so great, still the snow deposit is as great and as widely diffused.

As another evidence of moisture being a controlling element in the growth of trees, wherever a spring starts out of a mountain-side, otherwise treeless, a clump of timber marks the spot, and is an almost sure sign of its presence; and wherever a tree is planted and supplied with its requisite amount of water, the growth is as thrifty, as healthy, and as enduring as in its native forest.

INFLUENCE OF THE AURORA ON THE TELEGRAPH.

By W. D. Sargent.

Harrisburg, Pennsylvania, *September* 27, 1870.

I take the liberty of laying before you some crude observations of mine on the effect of the aurora on telegraph lines on the nights of the 24th and 25th instant.

Saturday, September 24th, the wires were very much interrupted all the evening, and we supposed a storm was gathering in the west, but the appearance of the aurora between 8 and 9 p. m. discovered the real cause of the trouble. The light and flashes increased in brilliancy and

color up to about 11 o'clock, when the whole northwestern part of the heavens was a brilliant red, reaching to the zenith, the color fading gradually to the north to a strong white light, and then rising again in the northeast, but not so brilliantly as in the northwest. At this time (11 p. m.) I came to the office and had one of our lines disconnected from the batteries and the ends grounded at Harrisburg and Philadelphia. This arrangement gave a current a trifle stronger than the regular batteries and in the same direction, galvanometer deflecting to the right. At 11.45, after one or two breaks, the current changed, the galvanometer needle deflecting to the left; at 11.55 back to the right; at 12.10 to the left, where it remained until 1 o'clock, when I went home.

After the galvanometer needle deflected to the left, at 11.45, the current became very unsteady and weak; was only sufficiently strong to move the relay for a few minutes at a time. The galvanometer showed a current of varying strength all the time.

Sunday, September 25th, the aurora again appeared about 8.30 p. m., but not near so brilliant as on the former evening.

I had a wire connected as before, viz, to the ground at Harrisburg and Philadelphia. This produced no effect whatever on the relay. The galvanometer at 8.40 deflected to the left; 8.45, right; 9, left; 9.20, right; 9.21, left; here the current was very changeable, the needle fluttering from side to side; at 9.22 again to the right, where it remained until 10 p. m., when I went home.

The galvanometer I have is Dr. Werner Siemen's universal galvanometer.

[The change in direction of the current may possibly have been due to the greater action of a beam of the aurora on the easterly part of the wire between Harrisburg and Philadelphia, and afterward of another beam on the westerly part of the wire. It is therefore important to note whether a change of a similar kind takes place in a wire extending north and south.—J. H.]

METEOROLOGY.

NEW CLASSIFICATION OF CLOUDS.

By Professor Andre Poëy,
Late director of the observatory at Havana.

HISTORICAL SKETCH.

The meteorologists of antiquity felt the need of distinguishing the different appearances of clouds, but were, at the onset, completely bewildered by the great variety of form which they assumed, apparently without order. Aristotle* first studied the phenomena of clouds in relation to their optical properties—their power of reflecting and refracting light, and the production of rainbows, halos, and coronas. Theophrastus,† his disciple, afterward vaguely observed the forms of clouds relative to the predictions of change of weather. He remarked, for example, that the appearance of straight horizontal layers of clouds on the summits of mountains is an indication of wind and rain; but these attempts evidently must have failed, because the natural classification of objects in the time of Theophrastus was unknown. It was not until 1801 that the great naturalist Lamarck,‡ and in the year after the celebrated English meteorologist Luke Howard,§ perceived the possibility of referring the clouds to some fundamental types, following the example of the natural classification for living beings adopted by Linneus. Lamarck, who pointed out the importance of the study of the forms of clouds, determined six principal types, which he denominated clouds *en balayures*,

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* Aristotle.

† Theophrastus.—Liber de ventis, et opuscula de signis pluviarum et tempestatis, auct. Theophrasto, in lat. vers. et illustr. apud Franciscum de Franciscis Bonaventura, Venetiis, 1594, 4 parts, 1 vol., 4to; Eresii Theophrasti qua supersunt opera et excerpta Librorum quatuor tomis comprehensa Jo. Gottlob Schneideri, Lipsiæ, 1818–'21, 5 vol., 8vo, vol. ii, pp. 466–476, 599–605; vol. iv, pp. 719–756; vol. v, pp. 163–173.

‡ Lamarck.—Annuaire meteorologique, Paris, an x, No. 3, p. 149; an xi, No. 4, pp. 126–128; an xii, No. 5, p. 159.

§ Howard.—Tilloch's Philosophical Magazine, 1803, vol. xvi, pp. 97–107, 344–357; vol. xvii, pp. 5–11, pl. vi, vii, viii, with some changes not affecting the nomenclature in Ree's Cyclopædia, 1819, vol. viii, art. *cloud;* in Nicholson's Philosophical Journal, 1812, vol. xxx, pp. 35–62, without plates; in supplement to the Encyclopædia Britannica, 1824, vol. iii, pp. 202–205, art. *cloud*, with plates, and the addition of a set of new terms for the modifications, intended for the use of English readers; The Climate of London, London, 1833, vol. i, pp. xxxix–lxxii; On the Modifications of Clouds, and on the Principles of their Production, Suspension, and Destruction, being the substance of an essay read before the Askesian Society in the session from 1802 to 1803, issued separately, in 1832, London, 8vo., without plates; id, London, 1864, in 4to, with lithographs.

(sweeping;) *en barre,* (bars;) *pommelés,* (curdled;) *groupés,* (grouped;) *en voile,* (veil;) and *attroupés,* (piled.) The year following, 1802, Luke Howard proposed a classification of clouds still more elaborate than that of Lamarck. It is a remarkable fact that these two savants, who labored independently of each other on clouds observed in two different countries, should have arrived at almost the same fundamental types, and especially at the determination of the same clouds, though designated by different denominations. Thus, in the seven types which Howard has established, we find the first five types of Lamarck, according to the following table:

Types of Lamarck.	Types of Howard.
En balayures, (sweepings)	Cirrus.
En barre, (bar)	Cirro-stratus.
Pommelés, (curdled).	Cirro-cumulus.
Groupés, (grouped)	Cumulo-stratus.
En voile, (veil)	Nimbus.

As to the two other clouds of Howard, the *stratus* being but a mist, and the *cumulus* corresponding entirely to his own *cumulo-stratus,* since he made double use of these identical forms, we see how the five true types of Howard are fundamentally the same as those of Lamarck. If we consider that my new type of *fracto-cumulus* is found in the classification of Lamarck under the name *nuage attroupé,* (piled cloud,) adding besides my two other types of *pallio-cirrus* and of *pallio-cumulus,* the last being a modification of Howard's *nimbus,* we have the classification of clouds established by me in 1863, which I shall describe in the following exposition. The types which served as the base of Howard's nomenclature were very happily chosen, since, as Kämtz well observed, they are connected with anterior atmospheric changes, and consequently furnish us with indications of approaching change of weather. Howard in his classification, which is almost entirely based upon the form of the clouds, distinguishes three simple modifications: The *cirrus:* parallel flexions, or diverging fibers, extensible by increase in any or in all directions; the *cumulus:* convex or conical heaps increasing upward from a horizontal base; the *stratus:* a widely extended, continuous, horizontal sheet, increasing from below upward, from which the two following intermediate modifications are derived: The *cirro-cumulus:* small, well-defined, roundish masses in close horizontal arrangement or contact; the *cirro-stratus:* horizontal, or slightly inclined masses attenuated toward a part or the whole of their circumference, bent downward or undulated, separate or in groups consisting of small clouds having these characters; and, finally, the two following compound modifications: The *cumulo-stratus:* the *cirro-stratus* blended with the *cumulus,* and either appearing intertwined with the heaps of the latter, or *superadding a wide-spread structure to its base;* the *cumulo-cirro-stratus vel nimbus:* "The rain-cloud, a cloud or system of clouds from which rain is falling. It is a horizontal sheet, above which the *cirrus* spreads, while the *cumulus* enters it laterally and from beneath." I shall point

out below the faulty interpretation which has been given by all the writers to the description of Howard's two types of clouds, the *stratus* and *nimbus*, then the defects of this nomenclature, which I reject, and the new classification which I substitute, although since the time of Howard no other classification having been hitherto proposed, the following are some partial attempts which have been made on the subject.

In 1815 Thomas J. M. Forster* reproduced, with some remarks, Howard's description of clouds, adding an English nomenclature of common names. In 1817 A. Müller† proposed the removal of some obscurities in Howard's descriptions, founded upon observations which he had carried on for twenty years at Vienna, in the north of Germany, upon the northern and southern slopes of the Alps, on the banks of the Rhine, and in France. In 1832 the celebrated meteorologist Kämtz‡ determined a new form of clouds under the name of *strato-cumulus*, or night-clouds; that is to say, the reverse of Howard's *cumulo-stratus*. But before his death, M. Kämtz himself acknowledged to me that he no longer attached any importance to his *strato-cumulus*, and that I could erase it from the nomenclature of couds. In 1857–'58 W. S. Jesons§ published two notes upon the form of *cirrus* and other clouds. He endeavored to account for their formation by laboratory experiments, which he had made with vapor of water. In 1863 the lamented Admiral Fitz Roy,|| having in charge the meteorological department of the Board of Trade, (London,) proposed the adoption of an augmentative termination in *onus*, and a diminutive in *itus*, to the nomenclature of Howard, in the following manner: From *cirrus* he forms *cirronus* and *cirritus;* from *cirro-stratus*, *cirrono-stratus* and *cirrito-stratus*, and so on. Not only does this modification refer to the less or greater quantity of clouds without changing the primitive form, but it is subject to great error in practice without being warranted in this by either the observation or the plates of Fitz Roy. Finally, in 1863, I proposed to the Academy of Sciences of Paris the determination of the new types, which I have named *pallium* (*pallio-cirrus* and *pallio-cumulus*) and *fracto-cumulus*, the description of which will be found farther on.¶ When one considers the imperfection of Howard's old classification, the difficulties of distinguishing each stratum of clouds,

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* FORSTER.—Untersuchungen über die Wolken und andere Erscheinungen in der Atmosphäre, Aus. d. Franz, 2. Auflage, Leipzig, 1819; Researches about Atmospheric Phænomena, London, 1815, 2d edition, pp. 1–113; id., London, 1823, 3d edition, pp. 1–113.

† MÜLLER.—Gilbert's Annalen der Physik, 1817, vol. lv, p. 102; Bibliothèque universelle de Génève, 1817, vol. v, pp. 6–12.

‡ KÄMTZ.—Lehrbuch der Meteorologie, Leipzig, 1831, vol. i, p. 377; Vorlesungen über Meteorologie, Halle, 1840; id., translated by Ch. Martins, Paris, 1843, p. 115, pl. iii.

§ JESONS.—Philosophical Magazine, 1857, vol. xiv, pp. 22–35; 1858, vol. xv, pp. 241–255.

|| FITZ-ROY.—The Weather Book, London, 1863, p. 391, pl. ix, x.

¶ POËY.—Sur deux nouveaux types de nuages observés à la Havane, denommés *pallium* (pallio-cirrus et pallio-cumulus) et fracto-cumulus—Comptes-rendus de l'Académie des Sciences de Paris, 1863, vol. lvi., p. 361; Annuaire de la Société Metéorologique de France, 1863, vol. xi, p. 53.

with their corresponding elements, and especially the considerable length of time that an observatory must spend in making a good observation, according to our present faulty method, we are less surprised at the little progress that a study so interesting has hitherto made. I must add an important fact, which has passed completely unnoticed: that the classification of Howard also is faulty in the definition of *stratus* and *nimbus*. Kämtz's treatise on meteorology gives the following definition of *stratus*, which has been since blindly adopted by all meteorologists: "It is a horizontal *band*, formed at sunset and disappearing at sunrise." On the contrary, Howard's definition has always been that the *stratus* "is the lowest of clouds, since its inferior surface commonly rests on the earth or water; this is properly the cloud of the night, the time of its first appearance being about sunset. It comprehends all those creeping *mists* which, in calm evenings, ascend in spreading sheets (like an inundation) from the bottom of valleys and the surface of lakes, rivers, and other pieces of water to cover the surrounding country." In continuation, Kämtz, describing the *cirrono-stratus*, remarks that "these clouds form horizontal strata, which, at the zenith, seem composed of a great number of thin clouds, while at the horizon, where we perceive the vertical projection, we see a long and very narrow band." Thus for the *stratus* we have a horizontal band, and for the *cirro-stratus* at the horizon another band, *long and very narrow*. According to this savant, between these two bands there is no distinctive mark save the hour at which they appear. But as the bands *cirro-stratus* are frequent exactly at the rising or setting of the sun, it is very difficult to distinguish these two orders of clouds. It must be added that the *cirrus* and the *cirro-cumulus* show a tendency to dispose themselves in bands parallel with each other, which at the horizon may be equally confounded with those of *stratus* and *cirro-stratus*. As to the origin of the *stratus* can we, without confusion, give the name of cloud to a phenomenon already designated as *mist?* The sole connection which exists between a cloud and a mist is in the first precipitation of vapor of water in the atmosphere, and its greater or less condensation. It is when the mist is elevated to the region of inferior clouds that it is condensed under the form of a *cumulus*, and the visible vapor of water takes its first forms. Hitherto the mist was but a shapeless mass of vapor molded, so to speak, by the accidents of the earth and sheets of water, and following the permanent or transient outlines of these surfaces. It seems that Howard's first error was calling a mist a cloud, and the grave responsibility rests upon his successors of giving the mist of this writer as a true cloud under the form of a *horizontal band*. This error has been extended to the different plates published in 1815 by Forster, in which, nevertheless, the *stratus* is not given as a band, but rather as a mist raised at the horizon. But this representation is equally faulty, as it gives no idea of a mist covering the surface of the earth. As early as 1820, in Brande's* work, the *stratus* appeared as forming a *horizontal*

* Brandes.—Untersuchungen zur Witterungskunde, Leipzig, 1820, p. 385.

band, which was reproduced by Kämtz in 1840, and by Schübler* in his four splendid engraved plates in 1849. In fine, the plates which were published by the Smithsonian Institution† at Washington, and in 1859 by the chart department of the French minister of marine,‡ to serve as instructions for seamen and observers, were reproductions of those of Kämtz. The French edition alone contained two plates, of which the first embraced the simple forms of clouds, *cirrus*, *stratus*, *cumulus*, and *nimbus*, and the second the compound forms, *cirro-cumulus*, *cirro-stratus*, and *cumulo-stratus*, with four variable *cirri*. Howard's Plate VI, on the contrary, published in 1803 for the first time, in Tilloch's Philosophical Magazine, represents the *stratus* as a *mist* spreading above a lake surrounded by hills. Thus far in relation to the erroneous interpretation given to Howard's *stratus*. We now proceed to note another error hitherto propagated, relative to the *nimbus*. In the first place, Kämtz's definition, which all the late meteorologists have adopted, is as follows: When the *cumulus* is piled up and becomes more dense it passes to the state *cumulo-stratus*, which often takes at the horizon a black or bluish tint and passes to the state of *nimbus*, or rain-cloud. This is distinguished by its uniform gray tint and its broken edges, the clouds which compose it being so much confounded that it is impossible to distinguish them. Thus the single primordial and distinctive character which results from this definition is that of a rain-cloud, and therefore we shall call every rain-cloud *nimbus*, as has been done to the present time. Its secondary characteristics are: 1st, a tint of uniform gray; 2d, its edges broken; 3d, confusion of all the clouds of which it is composed. All this gives no idea of the most essential element, namely, the *real form* of the rain-cloud. Though the definition of Kämtz, and other writers, is not that of Howard, this observer has not given one more intelligible and exact. We see that he unconsciously felt the formation of rain-cloud, but was not very settled in his description. I am speaking of the *double superposed stratum*, the inferior formed of *cumulus*, which it designates, and the second superior stratum of *cirrus*, whose existence was vaguely felt by Howard. The remainder of his definition is *cumulus cirro-stratus vel nimbus def. nubes vel nubium congerieo (superné cirrata) pluvian effundens.* A cloud or system of clouds from which rain is falling is called a rain-cloud. It is a horizontal sheet, above which the *cirrus* spreads, while the *cumulus* enters in laterally and from beneath. In other isolated passages of his long description of the nimbus, the idea of this double stratum appears yet more plainly. "Clouds, in any one of the preceding modifications, may increase so as completely to obscure the sky. Before this effect takes place there exists, *at a greater altitude*, a thin, light veil, or at least a hazy turbidness.

* SCHÜBLER.—Grundsätze der Meteorologie, Leipzig, 1849.

† SMITHSONIAN INSTITUTION, Washington, D. C.

‡ VANEECHOUT.—French translation of the "Explanations and Sailing Directions of Lieutenant Maury," Paris, 1859, 4to.

When this has considerably increased we see the lower clouds spread themselves till they unite in all points and form one *uniform sheet*. It will rain during this state of the *two strata* of clouds, one passing beneath the other and each continually tending to horizontal, uniform diffusion, (the *superior stratum* is often seen in this case to partake of *cirrus*,) although they should be separated by an interval of many hundred feet in elevation. The intermediate space on these occasions is not supposed to be at any time free from a conducting medium of different watery particles, enabling the opposite electricities to neutralize each other." Hence we see that this description of Howard's *nimbus* has no connection with that given by Kämtz and the late writers, of a cloud intermediate in form, which, according to the latter, is supposed to have the property of producing rain. It is not the property of any cloud to produce rain, but it is produced by the reunion by the electric action and reaction upon the aqueous vapor of two superposed strata of clouds, the superior being *cirrus* and the inferior *cumulus*. It is this latter circumstance that Howard has neglected to properly establish. All the plates which have been published, not excepting that of Howard, give no idea of this double stratum which constitutes the rain-cloud, that is, the *nimbus* of Howard, or properly my *pallium*, (*pallio-cirrus* and *pallio-cumulus*.) I now proceed to point out the error equally inherent in the three orders of clouds denominated *cumulus*, *cumulo-stratus*, and *strato-cumulus*, and to show that they can all be reduced to the second type of *cumulus*. I remark, in the first place, a great confusion, or it may be a great similitude, between the *cumulus* and the *cumulo-stratus*; afterward I observe in the sky other cumuli, whose characters partake of more than these two types; for example, M. Kämtz's definitions, which are generally accepted. M. Kämtz says: "The cumulus is often seen in the form of a hemisphere, *reposing upon a horizontal base*. Sometimes these hemispheres are piled one upon the other, forming those great clouds accumulated at the horizon, which resemble at a distance mountains of snow."

Now for the *cumulo-stratus*: "When the *cumulus* is piled up and becomes more dense, it passes to the state of *cumulo-stratus*, which often takes at the horizon a black or bluish tint and passes to the state of *nimbus* or rain-cloud." Thus, it is sufficient that the *cumulus* be piled up and become *more dense* in order to be changed into *cumulo-stratus*, strikingly implying great development in the horizontal base, which is not mentioned, though it is one of the most essential characters of this type of clouds. While, on the other hand, this horizontal base is expressly pointed out in Kämtz's definition of *cumulus*. In a word, these fundamental points are found equally in the formation of *cumulus* and *cumulo-stratus*: 1st, a horizontal base; 2d, a superior hemispherical dome; 3d, a formation by increase from below upward. The points of difference as to the *cumulo-stratus* rest upon the irregularity of the base of the convex summits, and the aggregation from below upward;

upon the greater density, dark coloring, and semblance of their isolated masses to a mountain chain. These differences are so accidental and insignificant that Howard and Forster could not distinguish them in their definitions, and they are forced to aver that these characters were found here and there at such points that they were easily confounded. We see there is no reason to maintain a radical separation and a double denomination for two forms of clouds which are of the same kind and whose slight modifications are not even continued. It is therefore more exact to preserve the single denomination of *cumulus* for this second type, which embraces at once the two characteristic forms of cloud—on the one side the accumulation of hemispheres, and on the other the horizontal base, which are always inseparable.

Let us now pass to Kämtz's description of *strato-cumulus:* "It is composed of dense cloudy masses, round or extended, badly defined at the edges, which appear in the afternoon, increasing toward evening, until during the night the whole sky is completely covered, disappearing the next morning some hours before sunrise and finally replaced by the true *cumulus.* These *strato-cumuli* are composed of very dense versicular vapor, like the *cumuli* and *cumulo-strati.* They differ by their dependence on different hours of the day; they have also some analogy with the *strati* by reason of their extension, but are distinguished by greater altitude; yet they approach the cumuli. In winter the *strato-cumulus* often covers the sky during entire weeks; but as the sun approaches the zenith, his rays dissolve these clouds, the vapors rise, and the *cumuli* are formed." We find again in Kämtz's definition of *strato-cumulus* the same confusion as in Howard's description of *cumulo-stratus,* which I pointed out above. The terms "cloudy masses *rounded,* extended, or yet badly defined at the edges," embrace three expressions which are mutually exclusive, so that it is impossible to know the true form of the cloud, for if the cloudy masses are *rounded* they are not extended in Kämtz's sense, and still less are their *edges badly defined.* As to the physical constitution of the *strato-cumulus,* it is the same, according to Kämtz, as that of *cumulus* and *cumulo-stratus,* that is to say, composed of very dense versicular vapor.

In fine, "the *strato-cumulus* approaches the *stratus* by its exterior, but is separated from it by greater altitude." I have already said that we can compare the *stratus-mist* with no other form of cloud. Hence nothing remains but the hour of the appearance and disappearance of the *strato-cumulus,* (which seems to be the fundamental distinction Kämtz wished to establish,) to separate them from the *cumulus* and *cumulo-stratus,* added to their continuance in winter for whole weeks at a time. In a word, the *strato-cumuli,* with Kämtz, are the clouds of the night and of winter, predominating during the absence of the solar rays, and dissolved on the appearance of the sun. On this latter circumstance, we remark that the distinction of clouds of the night made by Kämtz and Howard appears to have no foundation; I have never been able

to perceive them. So true is this, that these two savants are nowise agreed upon this point, which has given rise to the new variety of Kämtz. With Kämtz, the cloud of night is the *strato-cumulus*, while with Howard it is the *stratus*. On the other hand, since the *stratus* is not a true cloud according to Howard himself, but simply a mist or hoar-frost, the distinction between the cloud of night and the cloud of day must become wholly superfluous. I will close this proof of the non-existence of *strato-cumulus* by reminding the reader that Kämtz himself told me before his death, without discussion, that he no longer attached any importance to his cloud of night, and authorized me to erase it from the nomenclature of Howard. In the exposition of my new classification of clouds, published in 1855, in the *Annual of the Meteorological Society of France*, while pointing out the identity of the *cumulus* and *cumulo-stratus*, I retained both these determinations, because the term *cumulus* did not designate its peculiar cloud-type as well as *cumulo-stratus*. But, as *cumulo-stratus* is derived from two species of clouds, it is preferable to keep the generic name of *cumulus* for the two identical clouds described by Howard, attributing to them the character given above.

DEFINITION OF CLOUDS.

Every country, according to its geographical position, topography, &c., has its own type of clouds. Here the *cirrus* predominates; there the *cumulus*. All these different appearances of clouds are everywhere intimately connected with some particular condition of climate, which powerfully influences health, agriculture, navigation, and a thousand other objects of importance to humanity. They show us at every instant the direction, the velocity, and the altitude of the superior currents which afterward determine the winds at the surface of the earth. We may regard the clouds as a weathercock in the sky, constantly indicating changes so long as a single one, however small, exists, and therefore a profound study of them, in their diverse, scientific, and social applications, becomes of high importance. For this we should consider their nature, form, quantity, direction, velocity, and azimuthal rotation.

Despite the scientific interest and the practical value which is attached to this subject, the study of clouds is unhappily in its infancy. It is rarely we find clouds included in the meteorological registers, and when they are so the characteristics above mentioned are omitted. Some observers simply write "clouds;" others denote the form, or, it may be, the quantity, the direction, or perhaps all these three elements, but neglect the velocity, and especially the azimuthal rotation to which I was the first to call attention and which is not yet understood.

We now proceed to present the basis of a new classification more in harmony with the actual facts of the science, and which is the fruit of twenty years' assiduous study of clouds in the Antilles, Mexico, the United States, and Europe. From the beginning of my meteorological investigations in the tropics, where the entire phenomena of the atmo-

sphere assume a character of simplicity unknown in higher latitudes, I have more and more felt the necessity of a reform of Howard's nomenclature. I was unable to understand his *stratus*, *nimbus*, *cumulo-stratus*, and *strato-cumulus*. It was not until I had an opportunity to consult Howard's original work that I perceived the errors into which Kämtz and other meteorologists had fallen. I had then to introduce into Howard's classification the modifications which the continued progress of meteorology requires, in order that the nomenclature may be more in harmony with our advances in this line. I acknowledge with pleasure that Howard's classification, which has existed without a rival for more than half a century, was originally based upon profound study, directed by great acuteness of observation; unhappily, however, it is too plainly stamped by the locality where his studies were prosecuted. I refer to the gray and cloudy sky of Great Britain, whence result his *strato-mist*, his imperfect distinction of the two great strata *cirrus* and *cumulus*, or his *nimbus*, (the rain-cloud,) the difference which he has established between *cumulus* and *cumulo-stratus*, besides many other faulty details of description in relation to *cirrus*, *cirro-stratus*, and *cirro-cumulus*.

I shall now proceed to give the derivation of my three new clouds. When certain clouds spread out uniformly over the whole face of the heavens and assume a gray or ash color, under which state rain may occur for hours or whole days, what name do we give them? They are not Howard's *nimbus*, as we conceive them, and as they are generally described; they are neither stormy nor electrical; they yield only a fine and continuous rain. Under this stratum we see constantly other clouds of more or less extent, but always isolated, becoming lost in it and increasing its thickness. But just before this stratum begins to break up, and during this operation, we see these same formless fragments detach themselves and fly to other regions. This inferior stratum is not alone; for when its disruption is completed we see through it another stratum of clouds, whiter and less dense, which breaks up in its turn, and ends by disappearing in an opposite direction to that of the inferior stratum. Have we a name for this variety of cloud so common in time of rain from the inter-tropical regions to high latitudes, especially in winter during the fall of snow? Does Howard's term *nimbus* and his description of it answer for its designation? Certainly not. We apply the name *nimbus* to the single storm-cloud, as well as to this inferior stratum, or to the united strata, and this without electrical manifestations. To this cloud I give the name *pallium*. When the superior stratum is formed of *cirrus* it constitutes the *pallio-cirrus*, and when the inferior stratum is formed of *cumulus* it constitutes the *pallio-cumulus*. The fragments of clouds, which differ entirely from the *cumulus* or *cumulo-stratus*, are the *fracto-cumulus*.

From what has been said, the necessity of distinguishing these two strata by different names is evident; but this necessity results, more-

over, from the fact that the stratum of *cirrus* is formed many hours, and even days, before that of *cumulus*, especially in the equatorial regions, and disappears after it. Without this distinction, we are obliged to call the first stratum of the *pallium cirrus*, and the second *cumulus;* but as, under this state of strata, the form and physical properties of *cirrus* and *cumulus* change completely, confusion and errors continually result.

Regarding Howard's classification as a whole, while retaining the two types of *cirrus* and *cumulus*, together with his two derivative clouds, *cirro-stratus* and *cirro-cumulus*, I reject entirely his *stratus*, *nimbus*, and *cumulo-stratus*, as well as the *strato-cumulus* of Kämtz, for the following reasons: The *stratus*,* because it is not (according to Howard) a cloud properly so called, but a *mist*, or *hoar-frost*, or the effect of optical illusion, a *cirrus*, *cirro-stratus*, or *cirro-cumulus*, seen in perspective near the horizon; the *nimbus*, for the reason that the name is an inexact denomination applied to an idea as vague as it is incorrect from the moment that *cumulus* is not truly rainy, as far as it is found displayed, forming a stratum as dense in appearance and below a second superior stratum of *cirrus*, equally rainy; the *cumulo-stratus*, because it differs in nothing from *cumulus*, according to Howard's own definition, these two forms possessing in common the three fundamental characteristics of his cloud-types and their derivatives, namely, horizontal bases, superior hemispherical basins, and the ascending aggregation of their aqueous particles; and, lastly, *strato-cumulus*, (Kämtz's cloud of night,) because this modification answers no better to *clouds of night* than Howard's *stratus*, and because its other characteristics correspond to *cumulo-stratus*.

On the other hand, as I have said before, I substitute for *nimbus* the *pallium*, which I subdivide into *pallio-cirrus* and *pallio-cumulus*, according as its stratum is composed of *cirrus* or *cumulus*. This term has the triple advantage of embracing the character, the form, and the effect, as the *cirrus* or *cumulus* forms the rainy stratum. I introduce, in fine, the definition of a second intermediate form, which can be rigorously distinguished from the preceding by the double relation of cause and effect. This is the *fracto-cumulus*, fragments of cloud floating about without determined form. Before their transformation into *cumulus*, they are precipitated or detached from the inferior surface of *pallio-cumulus*, and are spread out in horizontal bands at the top of the *cumulus* on the approach of gusts of wind. These *fracto-cumuli* differ from the *cumulus* in that they have neither the horizontal base nor the superior hemispherical form, while they are not much extended; but when they are a little more increased we see at once forming at the center of the fragment a space more dense and blackish than the rest, which gradually settles until it constitutes the horizontal base of the *cumulus*, (*vel cu-*

* In Howard's Plate VI, published in Tilloch's Philosophical Magazine, in 1803, he represents this cloud as a mist spreading above a lake surrounded by hills. All succeeding meteorologists have misunderstood this plate, and given the *stratus* as a band spread out at the horizon.

mulo-stratus,) the upper part becoming rounded by degrees. Thus the *fracto-cumulus* is the infancy of the *cumulus*, otherwise called *cumulo-stratus*, the terms being synonymous.

This new classification is wholly based upon the *nature*, the *form*, the *quantity*, the *direction*, the *velocity*, and azimuthal rotation of the clouds of each stratum, fully characterized by the origin, intimate constitution, and meteoric products of the vesicular vapors and congealed particles which constitute them; for, in the intimate nature of clouds, there is one fundamental condition to be established, depending upon the physical force which first acts upon their constitution: it is the element of *heat*. Clouds are therefore distinguished into *snow-clouds* and *ice-clouds*, of which the constituent particles are more or less congealed; then into clouds of aqueous vapor, of which the vesicles, empty or full, float in a medium above the freezing-point.

Under this fundamental aspect, there are but two types of clouds, properly so called, the *cirrus* and the *cumulus*. To the *cirrus* are attached three transitional forms, the *cirro-stratus*, *cirro-cumulus*, and *pallio-cirrus*; and to the *cumulus*, two other transitional forms, the *pallio-cumulus* and the *fracto-cumulus*.

The following is a table of my new classification of clouds compared with that of Howard:

NOMENCLATURE OF HOWARD.

First type	*Cirrus.*
Derivatives	Cirro-stratus. Cirro-cumulus.
Second type	*Cumulus.*
Derivatives	Cumulo-stratus.
Third type	*Stratus.*
Derived from the three types	Nimbus.

NEW NOMENCLATURE OF POËY.

First type	*Cirrus*	Ice clouds; snow clouds.
Derivatives	Cirro-stratus Cirro-cumulus Pallio-cirrus	
Second type	*Cumulus*	Clouds of aqueous vapor.
Derivatives	Pallio-cumulus Fracto-cumulus	

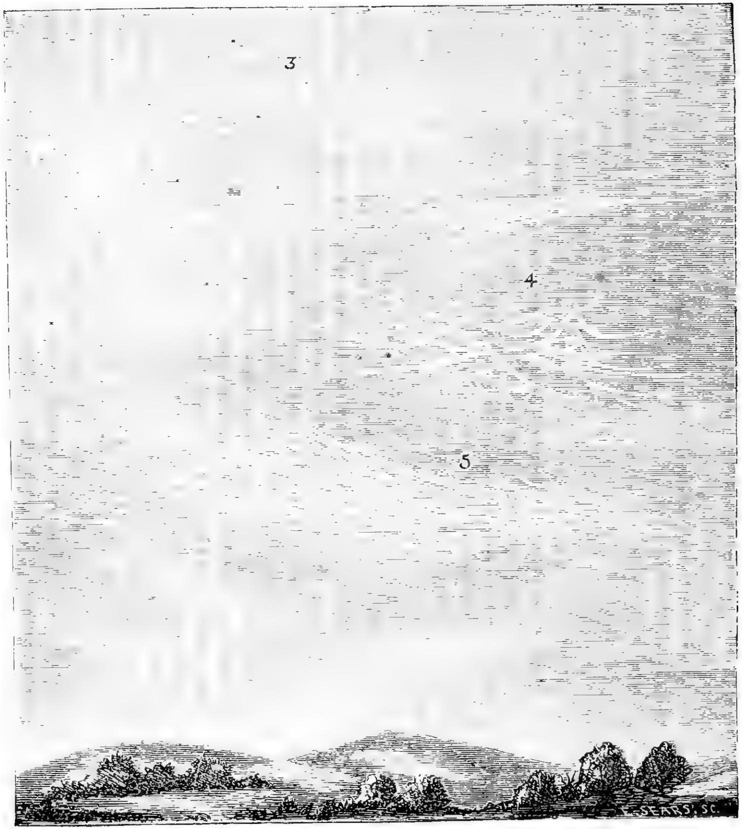
The nomenclature I have adopted appears more in accordance with the nature of clouds, for this reason, that the two types, *cirrus* and *cumulus*, are strictly based upon the constitution of *ice* and *snow* clouds and of clouds of aqueous vapor; while there is no proof of the existence of Howard's third type, since, according to this savant, it is a *mist* which overspreads the earth at sunset, but is raised in the morning at the first appearance of the sun. My nomenclature offers the same number of cloud forms; that is to say, seven, two types and five derivatives.

The order in which the clouds are placed in my table corresponds at the same time to the order of their appearance, from the highest regions

ILLUSTRATION OF CLOUDS.

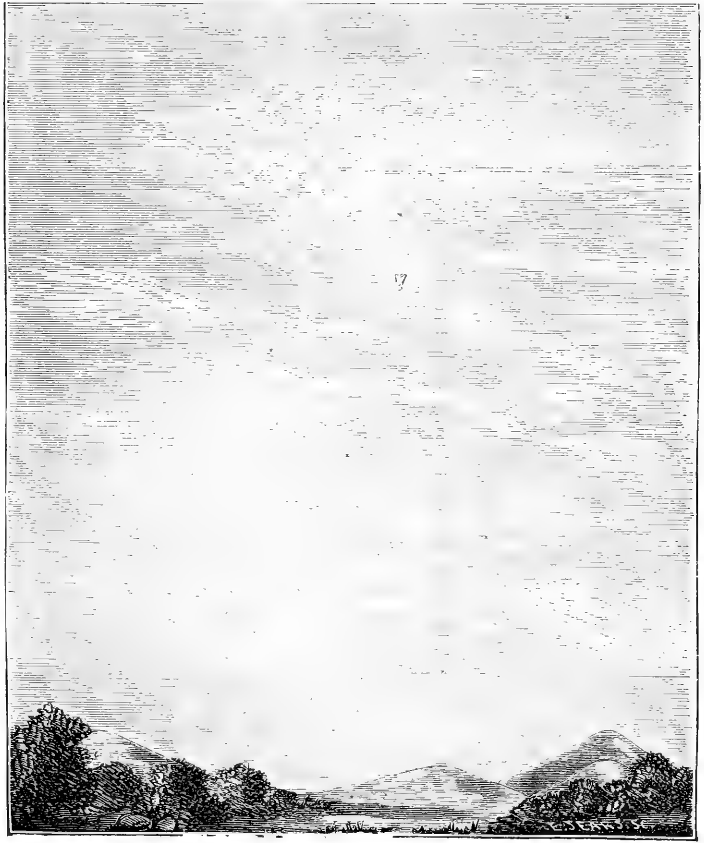
No. I.

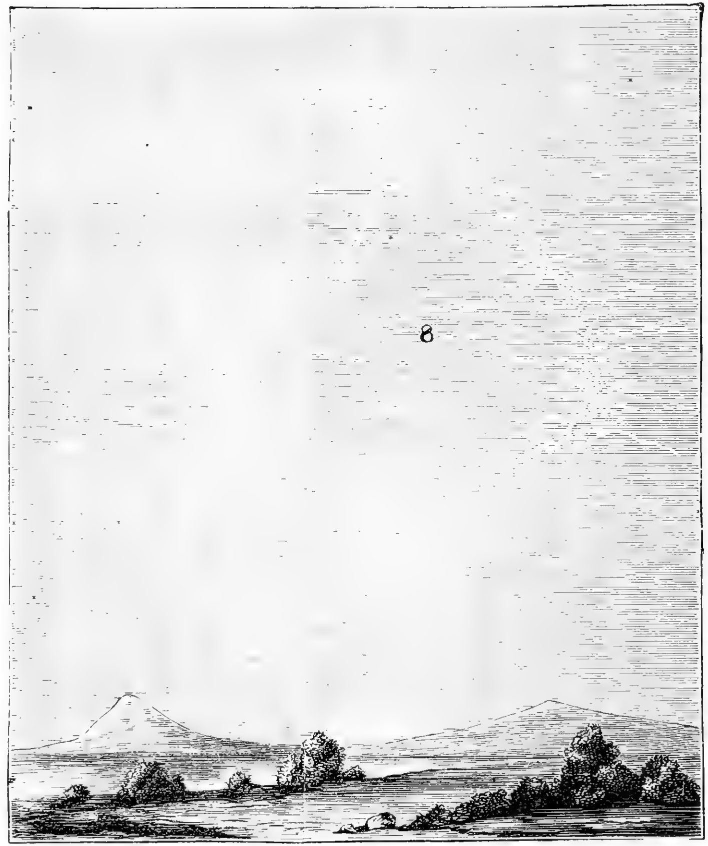
No. II.



CIRRUS (HOWARD) CURL-CLOUDS.—More than six and one-fourth miles in altitude. Figs. 1 and 2, cat's tails; figs. 3 and 4, twisted tufts; fig. 5, plumage; fig. 6, horse's tail.

No. III. ILLUSTRATION OF CLOUDS. No IV.





CIRRUS (HOWARD) CURL-CLOUDS.—More than six and one-fourth miles in altitude. Fig. 7, fine pencils; fig. 8, longitudinated and palmated bands.

of the *cirrus* down to those nearest the earth where the *fracto-cumulus* is produced, as the vapor of water passes from the state of frozen particles to that of aqueous globules, or *vice versa.* However, the *pallio-cumulus*, which serves as a transition from the two types and their derivatives, is found a little more elevated than the *cumulus.*

I have thought it proper to modify Forster's nomenclature by substituting names more in harmony with the form and nature of clouds. I give, in continuation, the old and the new classification:

	Forster's nomenclature.	Poëy's nomenclature.
Cirrus	*Curl*-cloud	*Curl*-cloud.
Cirro-stratus	*Wane*-cloud	*Thread*-cloud.
Cirro-cumulus	*Sonder*-cloud	*Curdled*-cloud.
Pallio-cirrus		*Sheet*-cloud.
Cumulus	*Stacken*-cloud	*Mount*-cloud.
Pallio-cumulus		*Rain*-cloud.
Fracto-cumulus		*Wind*-cloud.

With the exception of cirrus, whose name *curl*-cloud approaches nearest the form of that cloud, all the determinations have been changed. The *pallio-cumulus* replaces the *nimbus*, also named *rain*-cloud.

I.—CIRRUS, (HOWARD.)

Curl-cloud—cirrus, so named by Howard, (the "cat's-tail" of sailors, illustration No. I, figs. 1, 2,) is composed of filaments which resemble a twisted tuft of curled hair, (illustration No. I, figs. 3, 4,) plumage, (fig. 5,) the flowing tail of a horse, (illustration No. II, fig. 6,) or a fine pencil, (illustration No. III, fig. 7;) at other times are disposed in long, straight bands, parallel to each other, or divergent, palmated, or like a herring-bone or vertebral column, (illustration No. IV, fig. 8,) their greater axis oriented according to the sailing of the cloud and the direction of the wind at that altitude, which soon makes itself felt at the surface of the earth. When it forms two or more systems of straight, parallel bands, by an effect of perspective they appear to diverge from their point of departure at the horizon, and to converge toward the point of the horizon opposite, as do the rays of the rising and setting sun.

The cirrus is always white—sometimes brilliant, sometimes pearly-dull. The earliest and latest reflections of the solar rays upon these clouds color them with a delicate rosy tint, more or less intense, according to their density. Their movement is exceedingly slow, and their altitude is not less than 10,000 yards, (more than six and a quarter miles.) These clouds are the highest, apparently, slowest, most rarified, most variable in their forms, and the most extended. The appearance or disappearance of *cirrus* proclaims the end or the commencement of good weather. The barometer sinks and then rises, all the accompanying meteorological phenomena undergoing a similar change. We quote from Howard:

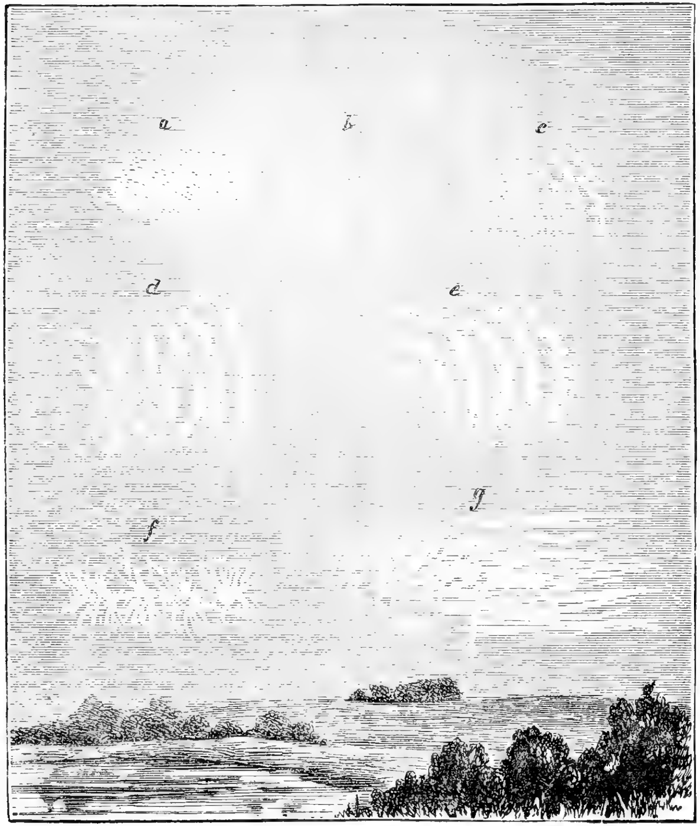
They are first indicated by a few threads penciled, as it were, on the sky. These increase in length, and new ones are in the mean time added to them. Often the first-formed threads serve as stems to support numerous branches, which in their turn give

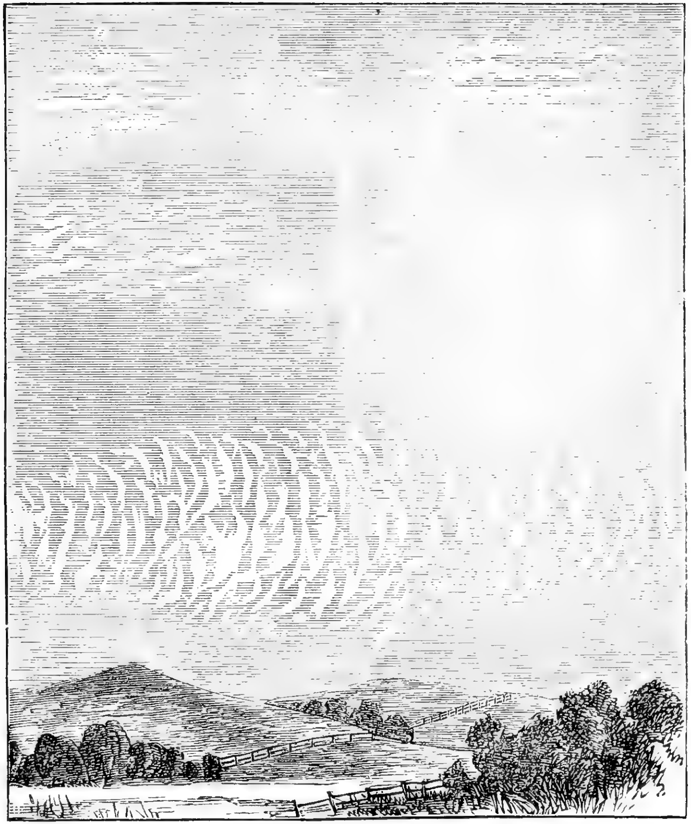
rise to others. The increase is sometimes perfectly indeterminate; at others, it has a very decided direction. Thus the first few threads being once formed, the remainder will be propagated in one or more directions laterally, or obliquely upward or downward, the direction being often the same in a great number of clouds visible at the same time; for the oblique, descending tufts appear to converge toward a point in the horizon, and the long, straight streaks to meet in opposite points therein; which is the optical effect of parallel extension. The upward direction of the fibers or tufts of this cloud is found to be a decided indication of *rain;* the downward as decidedly indicates fair weather. Their duration is uncertain, varying from a few minutes after the first appearance to an extent of many hours, and even days. It is long when they appear alone and at great heights, and shorter when they are formed lower and in the vicinity of other clouds. This modification, although in appearance almost motionless, is intimately connected with the variable motions of the atmosphere. Considering that clouds of this kind have long been deemed a prognostic of wind, it is extraordinary that the nature of this connection should not have been more studied, as the knowledge of it might have been productive of useful results. In *fair* weather, with light, variable breezes, the sky is seldom quite clear of small groups of the oblique *cirrus,* which frequently come on from the leeward, and the direction of their increase is to windward. Continued *wet* weather is attended with horizontal sheets of this cloud, which subside quickly and pass into the *cirro-stratus.* Before *storms* they appear lower and denser, and usually in the quarter opposite to that from which the storm arises. Steady, high winds are also preceded and attended by streaks running across the sky in the direction they blow in.

II.—Cirro-stratus, (Howard.)

Thread-cloud, (illustrations Nos. V and VI.)—Howard's *cirro-stratus* is distinguished from the pure *cirrus* by its filaments being smaller, more compact, more ramified, and, so to say, completely stratified. They are lower and more dense, for the sun's rays often pierce them with difficulty. Their whitish tint is clearer, and it becomes rose-color in similar circumstances. Their motion is a little more rapid. When at the horizon, we only seeing the vertical projection, they take the appearance of a long and very narrow band. According to Howard, "this cloud appears to result from the subsidence of the fibers of the *cirrus* to a horizontal position, at the same time that they approach each other laterally. The form and relative position, when seen in the distance, frequently give the idea of shoals of fish. Yet in this, as in other instances, the *structure* must be attended to rather than the *form,* which varies much, presenting at times the appearance of parallel bars, or interwoven streaks like the grain of polished wood. It is thick in the middle, and attenuated toward the edge. The distinct appearance of a *cirrus,* however, does not always precede the production of this and the last modification. The *cirro-stratus* precedes *wind* and *rain,* the near or distant approach of which may sometimes be estimated from its greater or less abundance and permanence. It is almost always to be seen in the intervals of storms. Sometimes this and the *cirro-cumulus* appear together in the sky, and even alternate with each other in the same cloud, when the different evolutions which ensue are a curious spectacle; and a judgment may be formed of the weather likely to ensue by observing which modification finally prevails. The *cirro-stratus* is the modification which

No. V. ILLUSTRATION OF CLOUDS. No. VI.



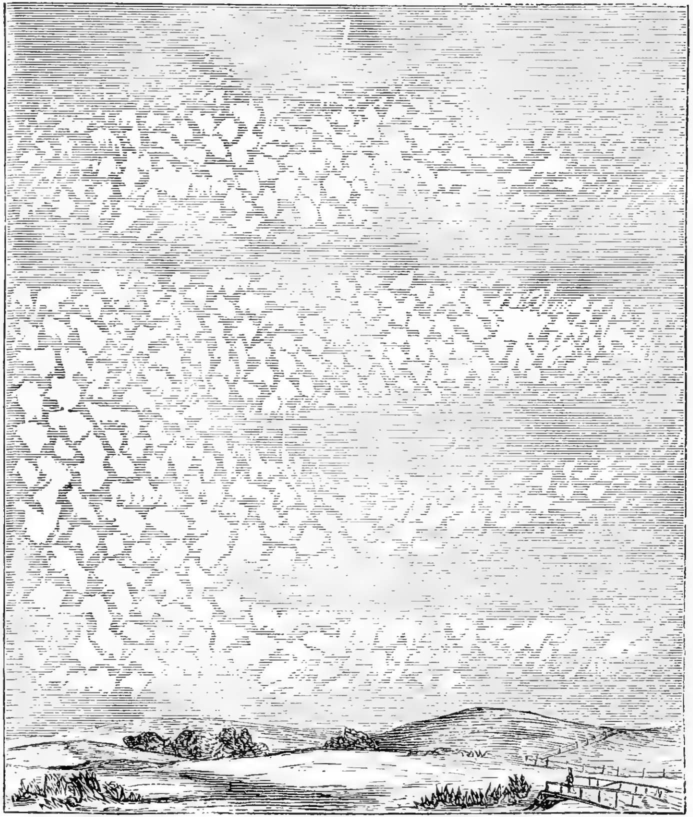


CIRRO-STRATUS (HOWARD) ICE-CLOUDS.—*a, b, c, d, e,* partial formation; *f,* perfect formation; *a, b, c, d, e, f, g,* nascent formation.

ILLUSTRATION OF CLOUDS.

No. VII.

No. VIII.



Cirro-cumulus (Howard) curdled sky.—Fig. 1, perfect type; fig. 2, bizarre form; fig. 3, irregular form.

most frequently exhibits the phenomena of the solar and lunar halo, and (as inferred from a few observations) also the parhelion and paraselene. Hence the reason of the prognostic of foul weather, commonly drawn from the appearance of halo. The frequent appearance of halo in this cloud may be attributed to its possessing great extent at such times with little perpendicular depth, and the requisite continuity of substance. This modification is, on this account, peculiarly worthy of investigation."

III.—Cirro-cumulus, (Howard.)

Curdled cloud, (illustrations Nos. VII and VIII.)—It is sufficient that the *cirro-stratus* sinks a little, or that the temperature of the region it occupies be slightly elevated, in order to give birth to Howard's *cirro-cumulus*. In the first place, the axes of the *striæ* grow round; then, by degrees, the entire stratification becomes so, until it resembles carded cotton, which we call *frizzled* clouds or *curdled* sky; in French, when it is completely covered, *moutonnés* or *pommelé;* in Spanish, *cielo empedrado*. On the contrary, if the *cirro-cumulus* is elevated a little, or the temperature is lowered, it returns to the type of *cirro-stratus*.

The *cirro-cumulus* is more dense and lower than the *cirro-stratus*, from which it is derived, though generally the edges of the small accumulations or of the entire mass of cloud are transformed into *cirro-stratus*, wherever, from a greater elevation or a lower temperature, the congelation is more vigorous. Its motion is also more rapid, its color slightly grayish, and it may be tinged rose-color or rather reddish.

The *cirro-stratus*, and especially the *cirro-cumulus*, is remarkable from a characteristic of the highest importance, which has escaped the sagacity of Howard and his successors, viz, the distribution of congealed aqueous vapor. It exists in the most fantastical combinations, reproducing all the formations of our continents and seas. Here, a deep bay with promontories, capes, peninsulas, isthmuses, &c.; there, a river, brooks, lakes, &c.; farther on vast continents and open seas. The outlines and the entire mass of each of these are besprinkled with *cirro-cumulus*, sometimes edged with *cirro-stratus*, whose volumes of little balls diminish and vanish from center to circumference, while in the empty spaces is the purest azure of the heavens. (Plate.) Should it be a lake, the water will be represented by the blue sky, and *terra firma* by the *cirro-cumulus* which surrounds it. By carefully studying all these transformations, we can observe in them a striking analogy to the phenomena of the precipitation and congelation of dew. There must be at this altitude, in the same stratum, one above the other, portions of the atmosphere having different degrees of density and of temperature, in order that the congelation of aqueous vapor should take place in so variable a manner.

The influence of *cirro-cumulus* upon the temperature at the surface of the earth is so marked that the human body feels it at once. A *curdled* sky at the new moon, on a calm night in the tropics, is a sky compara-

tively glacial, an effect probably due to the nearness and the quantity of snow which compose this type of cloud.

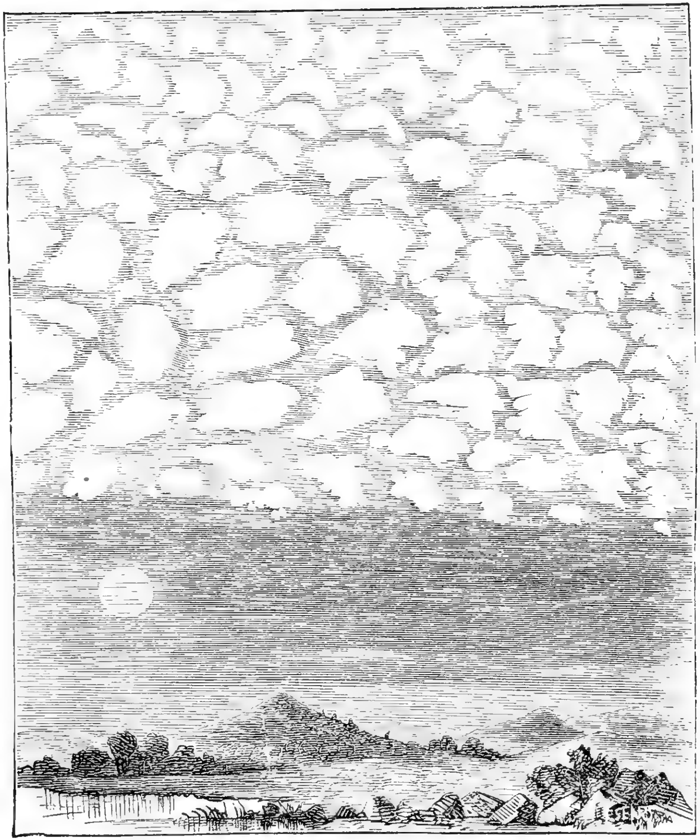
The *cirrus* being much more elevated and the *cirro-stratus* much less abundant, although both formed of glacial aiglets, have not the same influence on terrestrial temperature. According to Howard, the *cirro-cumulus* is formed from a *cirrus*, or a number of small separate *cirrus* by the fibers collapsing, as it were, and passing into small, roundish masses, in which the texture of the *cirrus* is no longer discernible, although they still retain somewhat of their relative arrangement. This change takes place either throughout the whole mass at once, or progressively from one extremity to the other. In either case the same effect is produced on a number of adjacent *cirri* at the same time and in the same order. It appears in some instances to be accelerated by the approach of other clouds. . This modification forms a very beautiful sky, sometimes exhibiting numerous distinct beds of these small connected clouds, floating at different altitudes. The *cirro-cumulus* is frequently seen in *summer*, and is attendant on warm and dry weather. It is also occasionally and more sparingly seen in the intervals of showers and in *winter*. It may either evaporate or pass to the *cirrus* or *cirro-stratus*.

IV.—Pallium, (Poëy,) (vel *nimbus*, Howard.)

Under the generic name of *pallium* I have classed two forms of cloud, which present the appearance of a mantle or veil of considerable extent, of very compact texture, well defined at the edges, of excessively slow motion, and embracing the visible vault of the sky. As the *pallium* is formed of *cirrus* or of *cumulus*, it is distinguished into *pallio-cirrus* and *pallio-cumulus*. The appearance of this cloud signalizes bad weather, and its disappearance, good weather.

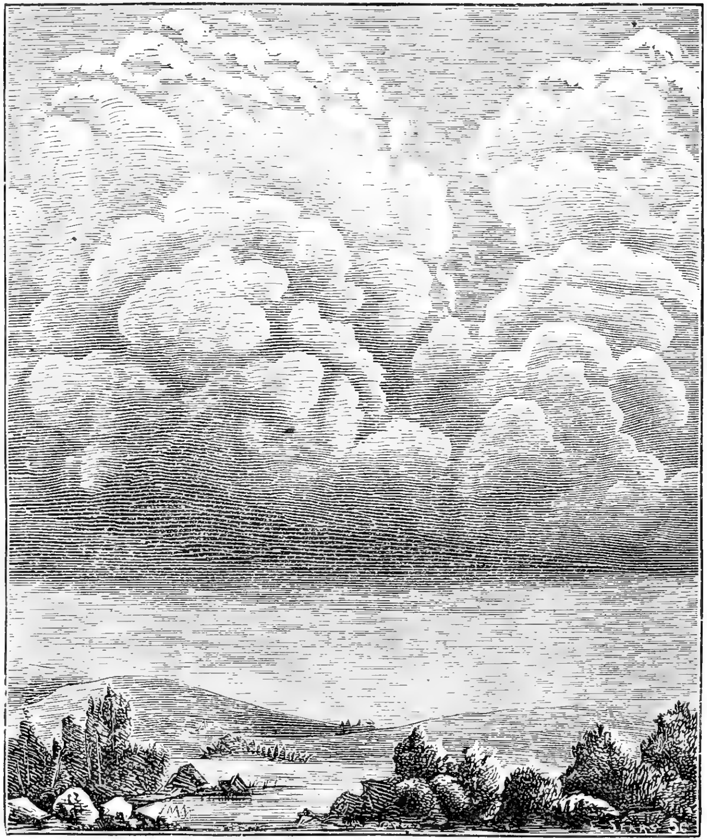
The stratum of *pallio-cirrus* is first produced, and some hours or days afterward that of *pallio-cumulus* is formed under it. These two strata remain in view at a certain distance from each other, and in their reciprocal action and reaction are accompanied with storms and heavy rains, and with considerable electric discharges. They are both electrified, but with contrary signs; the superior stratum of *cirrus* is negative, and the inferior one of *cumulus* is positive, the same as the rain which is disengaged, while the electricity of the air, at the surface of the earth, is negative. But when these two strata attract each other a discharge is produced, and the inferior stratum continues to pour out the surplus water it contained, without giving any sign of electricity, more than the air in contact with the earth. This state continues until the inferior stratum opens, afterward the superior, and then disappear, one after the other, fine weather succeeding. The *pallium* chiefly predominates during the rainy season, in tropical regions, and in the higher latitudes during winter, at the time of falls of snow. A part of the *pallio-cumulus*, which has not been reduced, or has not been scattered to other regions, gathers at the horizon, and is transformed into the *cumulus*. As to the

No. IX.



PALLIO-CIRRUS (POEY) SHEET OR SNOW CLOUD.—*a*, *b*, gradual formation; *c*, perfect type; *d*, veiled sun.

No. X.



CUMULUS (VEL CUMULO-STRATUS) (HOWARD) MOUNT-CLOUD.—*a*, perfect type.

pallio-cirrus, it disappears entirely if fine weather is maintained. Let us now see what are the inherent characters of the two *pallio*.

V.—Pallio-cirrus, (Poëy.)

Sheet-cloud, (illustration No. IX.)—The *pallio-cirrus* is formed by the accumulation of a *cirro-cumulus*, which is visibly sinking, or appears already formed toward a point of the horizon in the stratum, corresponding to this latter type. In the first case it is a little lower, more dense, less compact, more rapid in its movement, grayish, and often shows some traces of polarization. In the second case it is a little higher, less dense, more compact, less rapid, pearly whitish, impenetrable to the solar rays, and without a trace of polarization. In the two cases it appears generally in the south-westerly horizon, showing the presence of the superior equatorial current, and determining the fall of rain while it remains above and opposite the *pallio-cumulus*. When a breach is made in this inferior stratum it is speedily produced in that of the *pallio-cirrus;* sometimes it has already been formed in the latter. After the rupture of this stratum, the *pallio-cirrus* is transformed into *cirro-cumulus*, studded with *cirro-stratus*. On the approach of *pallio-cirrus* we observe the following meteorological manifestations: the barometer falls, the thermometer rises, the relative humidity increases, the tension of vapor diminishes, and a little after the wind at the earth is felt from that direction.

VI.—Cumulus, (vel cumulo-stratus,) (Howard.)

Mount-cloud, (illustrations Nos. X and XI.)—Howard's *cumulus*, (or *cumulo-stratus*,) summer and aqueous vesicle clouds, (the "cotton-balls" of sailors,) always appear in the form of a hemisphere or arcs of a circle, and repose upon a horizontal base. When these hemispheres are piled upon one another, there are formed great clouds accumulated at the horizon, similar to mountains in the distance covered with snow. Their contours take many forms, human, animal, and of every kind, more or less *bizarre* and fantastic, which inspired the poet Ossian with his finest images, and have given rise in mountainous countries to many popular traditions.

When the *cumulus* moves along the horizon, it is, excepting *fracto-cumulus*, the most rapid of all clouds. But when it is piled up along the horizon, in summer toward the south, in winter toward the north, it is excessively slow, and remains a whole day scarcely moving. It then extends perpendicularly or obliquely toward the zenith. Its roundish summit is of a glittering whiteness, and when elevated high enough, it is dyed rose color morning and evening like the *cirrus*. The center of the cloud is grayish, the base slate color or black. The base of the *cumulus* always rests upon the horizon, and is little elevated during a storm. It follows the direction of surface winds. Upon the plateau of the valley of Mexico, the *cumulus* completely disappears during the winter half of the year, and appears anew during the other six months. In summer it appears about eight or nine o'clock in the morn-

ing. It attains its highest elevation from two to three o'clock in the afternoon, during the greatest heat, after which it fades away gradually, and a little after sun-down disappears entirely behind the hills. Thus *cumulus* in Mexico is only visible in summer and during the day. Howard says:

Clouds in this modification are commonly of the most dense structure; they are formed in the lower atmosphere and move along with the current which is next the earth. A small, irregular spot first appears, and is, as it were, the *nucleus* on which they increase. The lower surface continues irregularly plane, while the upper rises into conical or hemispherical heaps, which may afterward continue long nearly of the same bulk or rapidly grow to the size of mountains.

In the former case they are usually numerous and near together, in the latter few and distant; but whether there are few or many, their *bases* lie always nearly in one horizontal plane; and their increase upward is somewhat proportionate to the extent of base, and nearly alike in many that appear at once.

Their appearance, increase, and disappearance in *fair* weather are often periodical and keep pace with the temperature of the day. Thus they will begin to form some hours after sunrise, arrive at their maximum in the hottest part of the afternoon, then go on diminishing, and totally disperse about sunset.

But in *changeable* weather they partake of the vicissitudes of the atmosphere; sometimes evaporating almost as soon as formed; at others suddenly forming and as quickly passing to the compound modifications.

The *cumulus* of *fair* weather has a moderate elevation and extent, and a well-defined, rounded surface. Previous to *rain* it increases more rapidly, appears lower in the atmosphere, and with its surface full of loose fleeces or protuberances.

The formation of large *cumulus* to leeward in a strong wind indicates the approach of a calm with rain. When they do not disappear or subside about sunset, but continue to rise, thunder is to be expected in the night.

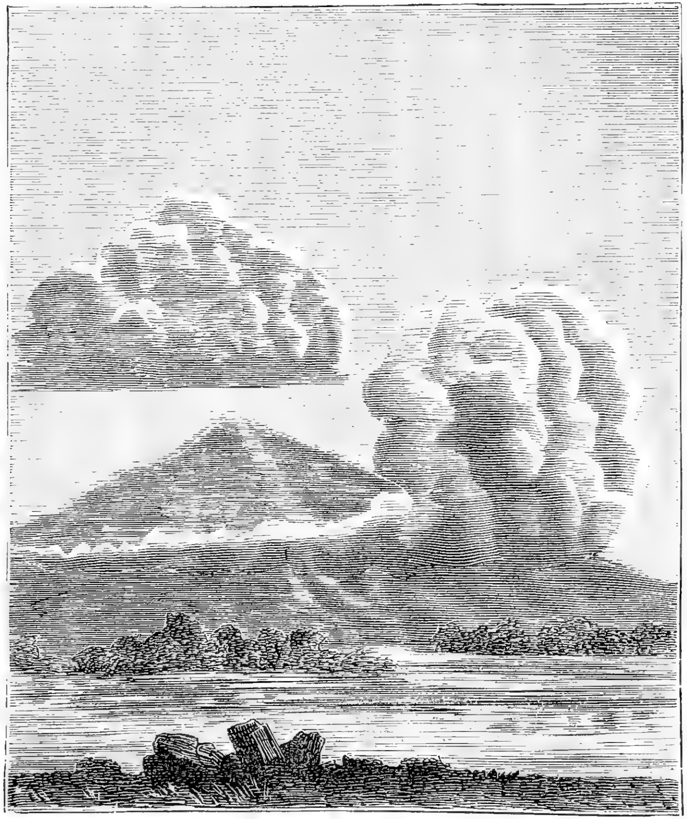
Independently of the beauty and magnificence it adds to the face of nature, the *cumulus* serves to screen the earth from the direct rays of the sun; by its multiplied reflections to diffuse, and, as it were, economize the light, and also to convey the product of evaporation to a distance from the place of its origin. The relations of the *cumulus* with the state of the barometer, &c., have not yet been enough attended to.

VII.—Pallio-cumulus, (Poëy.)

Rain-cloud, (illustration No. XII.)—The *pallio-cumulus* is produced by the accumulation of *fracto-cumulus*, which is gradually extended under the form of a uniform and compact stratum. This stratum is constantly sustained by the entrance of new *fracto-cumuli*, which increase its thickness until rain begins; then the *fracto-cumulus* ceases to penetrate it, and passes along the stratum of *pallio-cumulus*, but before the end of the rain it is disengaged anew from the stratum, which grows thin, is broken up and disappears. The *pallio-cumulus* is lower, more dense, less compact, more rapid than the *pallio-cirrus*, and is slate-colored or grayish. The thicker and more compact this stratum is, the longer will the rain continue; but as soon as a breach is made, it disengages fragments of *cumulus*, (*fracto-cumulus*,) which rapidly disappear, while the remainder are piled up at the horizon in the form of *cumulus*. The *pallio-cumulus* appears almost always from the northeast, showing the inferior polar current, which soon reaches the surface of the earth. The meteorological manifestations determined by them are inverse to those of *pallio-cirrus;* the

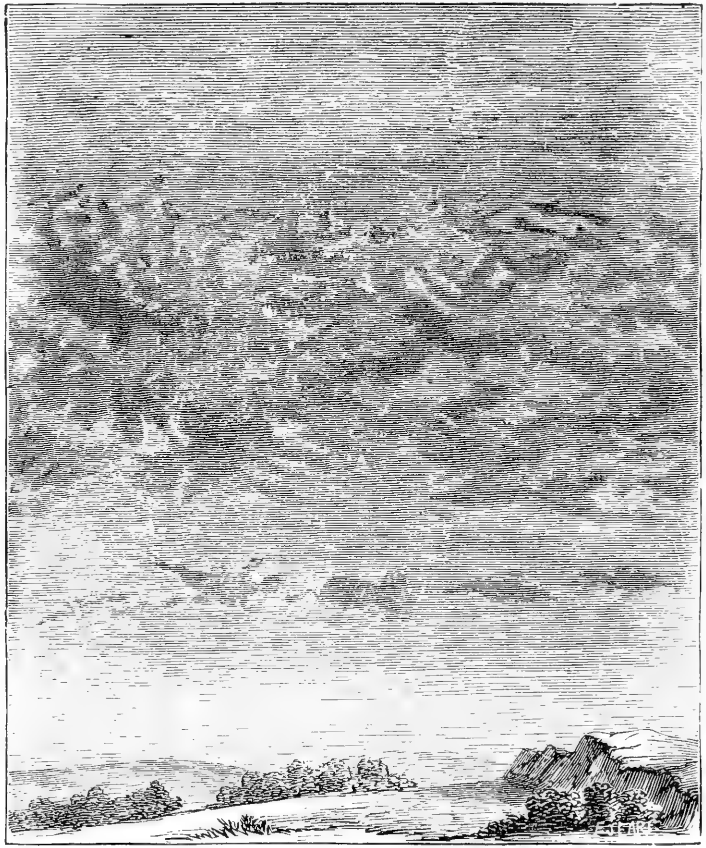
ILLUSTRATION OF CLOUDS.

No. XI.



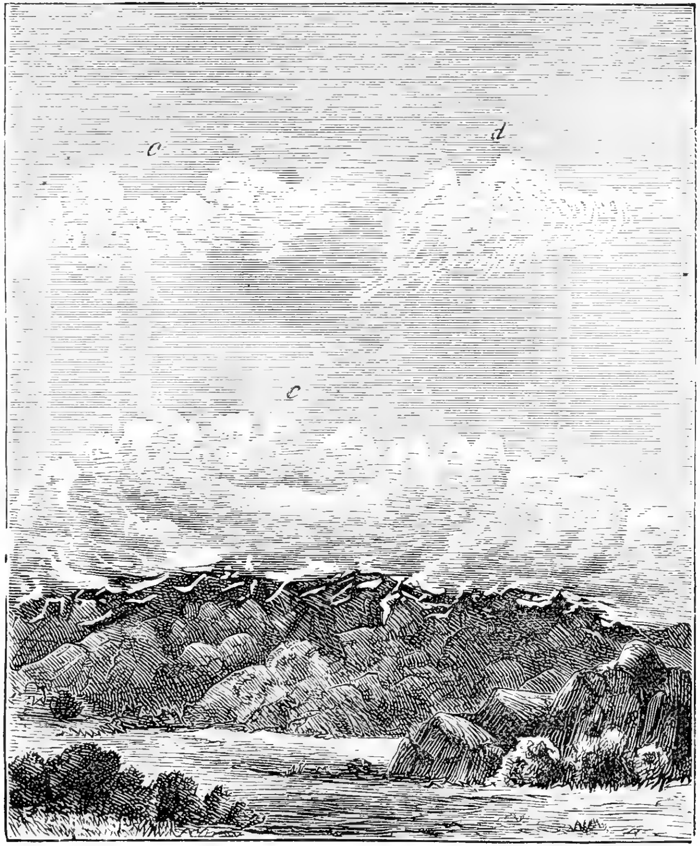
Cumulus (vel cumulo-stratus) mount-cloud.—*b*, *b*, nascent formation.

No. XII.



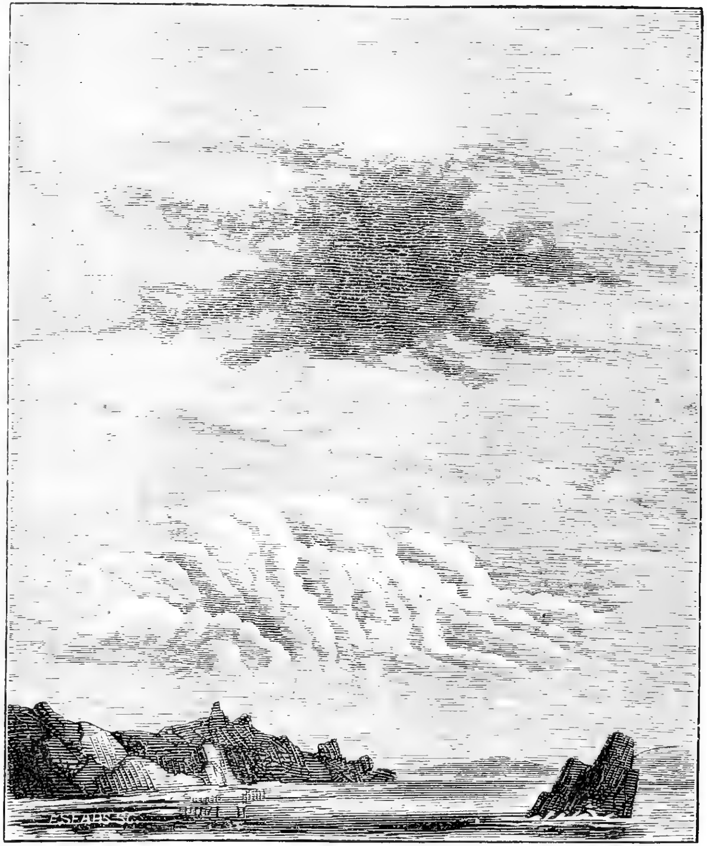
Pallio-cumulus (Poey) rain-cloud.—*a*, nascent formation; *b*, perfect type.

No. XIII.



Fracto-cumulus (Poey) wind-clouds.

No. XIV.



Fracto-cumulus (Poey) wind-clouds.

barometer rises, the thermometer falls, the relative humidity diminishes, and the tension of aqueous vapor increases.

VIII.—FRACTO-CUMULUS, (POËY.)

Wind-cloud, (illustrations Nos. XIII and XIV.)—The clouds which I have denominated *fracto-cumulus* are isolated fragments of *cumulus*, more or less considerable, without determinate form, jagged at the edges, the lowest and most rapid of all, and whitish, grayish, or slate-colored, according to their density. As soon as an invisible storm has broken out in the distance, we see them moving with great rapidity, almost grazing the highest buildings and tallest trees; their borders are greatly torn and white, contrasting strongly with the grayish stratum of superior *pallio-cumulus*. They are visible day and night, and often traverse the firmament from northeast to southwest without interruption for many days, while the sky above and in the intermediate space is perfectly clear. In winter we see them alone under a blue sky, sending in their passage to the zenith interrupted showers of rain, accompanied by strong gusts of wind, which occasion a very slight elevation and oscillation in the barometric column. In the Antilles these clouds produce the disagreeable winter rains, and in Europe the March storms. They generally follow the direction of the wind prevailing at the surface of the earth. When this wind is contrary to the direction of *fracto-cumulus*, it soon takes the same course.

A little before a storm or tempest arises, there appear a series of very small *fracto-cumuli*, which move rapidly, almost to two-thirds of their height, along a considerable mass of *cumulus*, which is stationed very often, as if immobile, near the southern horizon. Soon these *fracto-cumuli* become more abundant, less rapid, and form a horizontal band, which cuts the *cumuli* near their summit. This appearance is a warning sign for sailors, as it announces a squall. In fact, the *fracto-cumuli* become more and more developed; an exchange of opposite electricities takes place between them, and the storm quickly arises. It is, therefore, the same little cloud, of which I have spoken above, that, returning then from the combat, comes now to offer new battle. The aggregation of *fracto-cumulus* forms the *pallio-cumulus*, and increases and constantly maintains this stratum.

NATURE OF THE CLOUDS DEDUCED FROM THE FORMATION OF HALOS, CORONAS, AND RAINBOWS.

We can further distinguish the nature of clouds by the optical phenomena to which they give rise, according as their intimate constitution is more or less connected with a certain degree of aqueous vapor, in the state of snowy or glacial congelations of the strata corresponding to the formation of each type. The following are some facts which I have observed at Havana, which it is important to verify in other regions:

Generally speaking, *cirrus*, more especially *pallio-cirrus*, gives rise to a large solar and lunar halo of 22° radius. When it is produced by the

sun, it sometimes presents the seven colors of the spectrum, although usually there is only a single internal tint of orange, terminating at times in a little red. On the contrary, the great halo produced by the moon is almost always white, and seldom exhibits the tint of orange without the red.

The *cirro-cumuli* produce the lunar halo of about 2° to 4° radius, which may be triple or formed of sixteen prismatic rings with an internal tint of red. This halo is still more brilliant when it takes place, rarely enough, with *cirro-stratus*.

The *fracto-cumuli* are the only clouds which do not produce halos, but they do produce complete coronas or segments of arcs, according to the extent of the fragments which traverse the lunar disk. These coronas are also prismatic, having a blue internal tint.

The *pallio-cumulus* and the *cumulus* form neither halos nor coronas, but solar and lunar rainbows. In fine, aqueous vapor extremely dissolved, elastic, uniformly distributed in the higher regions of the atmosphere, without much altering the transparency of the air, gives rise to the formation of a *little* halo. Their unique coloration, in *brown* or *russet*, light or dark, as well as their size, is intimately connected either with the density of aqueous or elastic vapors or their altitude; their dimensions may vary from the borders themselves of the lunar disk up to 2° radius. We find them in every lunation.

QUANTITY OF CLOUDS.

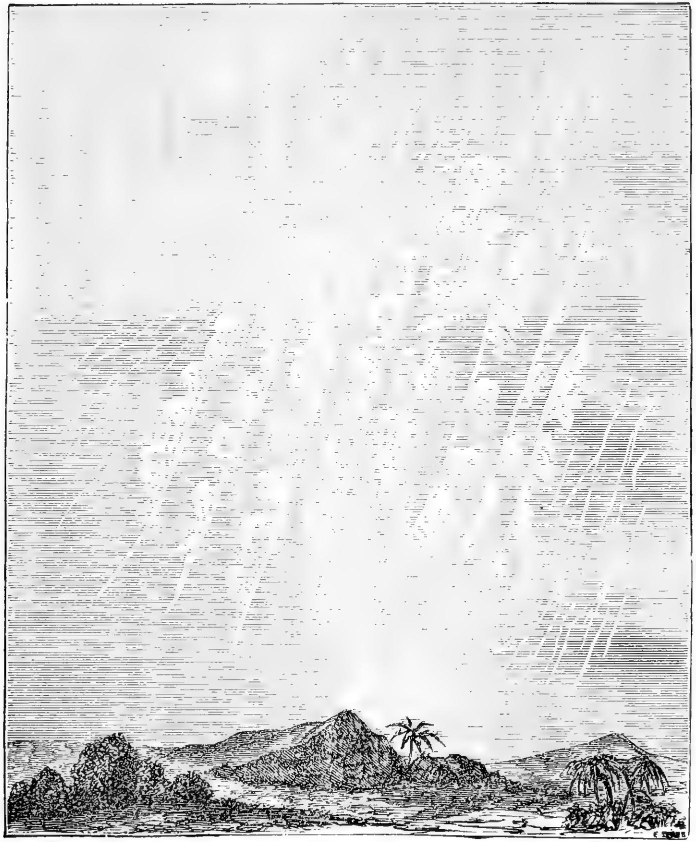
We measure by the eye the blue vault of the sky, or the quantity of visible clouds, which can then be determined according to a conventional scale in decimal fractions from zero (0) to unity, (1.) But it is preferable to take directly the quantity of clouds, and to repeat this calculation for each quadrant, upon each stratum and upon each type, instead of restricting ourselves to the *ensemble* of the sky, paying no attention to their nature, as has been hitherto everywhere done.

Here is the mode of proceeding: We explore the first quadrant, and if we find three different types of clouds—for example, the *cirrus* elevated, *cumulus* at the horizon, and *fracto-cumulus* low and isolated—we judge one after the other, according to their extent in height and breadth, the space which they occupy relatively to the 90° comprised from north to east, and from the horizon to the zenith of this quadrant. We then write for example in the corresponding columns 0.4 *cirrus*, 0.3 *cumulus*, and 0.2 *fracto-cumulus*. If the quadrant examined is completely covered by a single cloud, we mark unity, (1,) and its corresponding type. If, on the contrary, there is no cloud, we place 0. We repeat in turn the same operation in the three other quadrants, from southeast, from southwest, and from northwest.

At times the quantity of clouds associated with others of a different nature is so small, consisting merely of fragments, that it would be extremely difficult to make a just calculation, and then we mark *isolated*

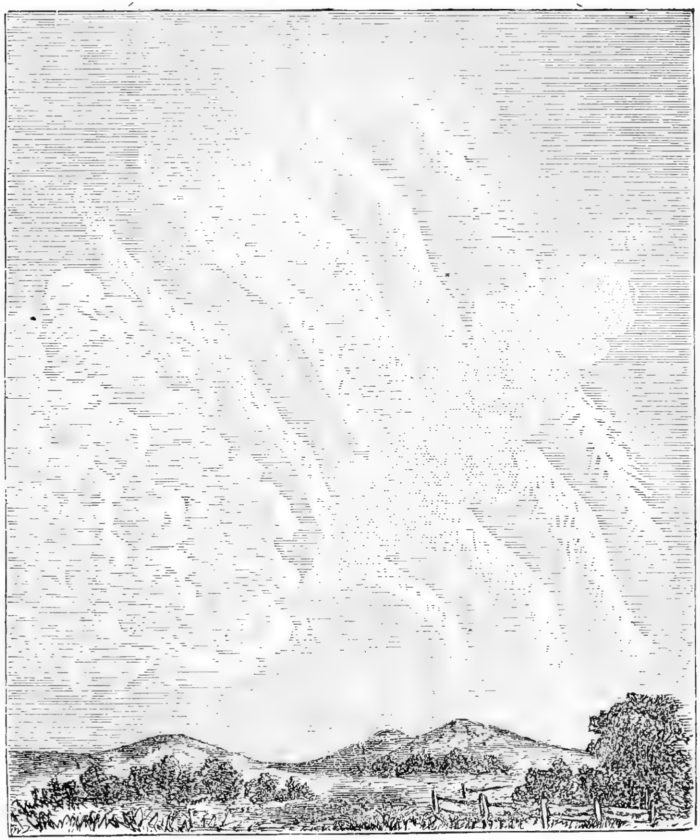
ILLUSTRATION OF CLOUDS.

No. XV.



Cirro-cumulus-stratus, (Poey.)—*a*, ice and snow clouds.

No. XVI.



Cirro-strato-cumulus, (Poey.)—*b*, ice and snow clouds.

(Observed only in Cuba in 1864.)

cloud of the corresponding type. During a continuous rain, when the sky is completely covered with a *pallio-cumulus*, we are sure to find above it a second stratum of *pallio-cirrus*, which occasions this rain. So after this examination we write in each quadrant unity for these two types. But as soon as a breach is made in the stratum of *pallio-cumulus*, then care must be taken not to confound the quantity of cloud corresponding to each of these two strata, which are perceived one after the other. With a little attention we come perfectly to know each order of cloud and the space it occupies.

DIRECTION OF THE CLOUDS.

We should note in another column the direction of each type of cloud corresponding to the first sixteen cardinal points of the compass. For this purpose, we must observe the space whence the cloud sets out, and that of the opposite horizon, where it is lost. When the cloud traverses the zenithal region, the observation can be easily made. There is only a single position which can give rise to error by an effect of perspective, which takes place morning and evening, when the *cumuli* are not removed from the limits of the horizon, where they have a very slow march and disappear at the opposite side in the same parallel plane. We think then that a cloud freely sets from east to west, or *vice versa*, either by the north or by the south, when it has rather an inclination from northeast, from northwest, from southeast, from southwest, or any other. If it is at sunrise or sunset, if the wind is from east to west, or if the vane remains stationary in one of these directions, we may be certain that the *cumulus* pursues this horizontal course perpendicularly to the meridian.

Often it is very difficult to grasp the direction of *cirrus*, because of its extreme slowness, and the considerable quantity and great extent of its filaments, which are oriented on every side. The attention must be principally fixed upon the side of the displacement of the ridge or central trunk whence this multitude of bands and lateral filaments is detached. The march of *cirrus* is then almost always in a longitudinal plane or parallel to the longer axis. By a law of perspective, the parallel bands appear to diverge from a point of the horizon, and on the other hand to converge toward another point diametrically opposite; but the observation of the point of convergence on the opposite horizon will give the mode of orientation.

There is another optical illusion, against which we must especially guard, in order not to commit a very grave error; for it appears each time that below a stratum of superior and very slow *cirrus*, we perceive a second stratum of inferior and rapid *cumulus*. In this case the *cirrus* seems to march rapidly in the opposite direction to that of the *cumulus*, when, in reality, it is following the same path, but more slowly. It is an illusion analogous to that remarked in a railway carriage when the objects closer to us file rapidly past in a direction contrary to that of the

locomotive; while objects more removed, beyond the second plane, move in the same direction. We cannot caution observers too much against this error, especially when there are three or four strata of superposed clouds, some having the same direction, and others opposite ones.

Very often, also, the *cirri* are so slow that it must take many hours to comprehend their march. This extreme slowness contributes to a lateral movement perpendicular to their advance still more pronounced than that of the *cumulus* or other types of clouds; to this must be added their filamentous form and the great number of their ramifications. In this case the observer must take a bench-mark upon some elevated structure in the city or the summit of a mountain or top of a tree, verifying it from hour to hour, and if these precautions are not yet sufficient, wait until the *cirrus* has passed the meridian or disappeared at the opposite horizon. Generally, at the observatory at Havana, the direction of *cirrus* is definitely noted upon the register only in the afternoon, although it has appeared at five or six o'clock in the morning.

When a *cumulus* is swelling up from a base below the horizon toward the zenith it presents the appearance of a motion which must be distinguished from the true direction of the cloud.

Cirrus, *cirro-stratus*, and *cirro-cumulus* come generally from the southwest, showing presence of the superior *equatorial* current.

Cumulus, *cumulo-stratus*, and *fracto-cumulus*, on the contrary, appear toward the northeast, determining the inferior *polar* current. But the *cumuli* from June to December generally take a middle direction, from the east, under the influence of the northeast and southeast trade-winds, while the *fracto-cumulus* accompanies the polar current from the northeast, from December to May, when this last, going against the current from southeast of the southern hemisphere, draws near the equator and causes the trade-winds to descend from north to east-northeast, or east.

Moreover, the *pallio-cirrus* and the *pallio-cumulus* serve alternately as a transition between these two opposite currents, the *equatorial* and *polar*, although the first type accompanies more frequently the superior current and the second the inferior current; so that these two *pallia* alternate in the following order:

$$\left.\begin{array}{l}\text{Cirrus,}\\ \text{Cirro-stratus,}\\ \text{Cirro-cumulus.}\end{array}\right\}\text{Superior equatorial current.}$$

Pallio-cirrus.
Pallio-cumulus.

$$\left.\begin{array}{l}\text{Cumulus.}\\ \text{Fracto-cumulus,}\end{array}\right\}\text{Inferior polar current.}$$

VELOCITY OF CLOUDS.

Our present uncertainty as to the velocity of clouds, the difficulties which are presented to a single observer, perhaps, deprived of sufficient knowledge or suitable instruments to undertake directly this calculation,

makes it only possible to determine it visually and approximately. As a general rule, clouds appear more rapid the nearer they are to the surface of the earth, and slower the farther they are removed from it. Therefore, the *fracto-cumulus*, which almost grazes the summits of mountains and tops of trees, is more rapid; while the *cirrus*, which is found in the torrid zone with an altitude of at least 10,000 to 15,000 meters, (six and one-fourth to nine and three-eighths miles,) is the slowest, seeing that it remains for hours at a time almost immovable.

We adopt the four following terms: *Slow, very slow, rapid, very rapid*, which suffice to express, with sufficient exactness, all velocities of clouds, because there is no case where we need a more minute nomenclature. The absolute determinations, especially *very rapid*, being the most difficult to seize, we must guard against making use of them before we are perfectly acquainted with the march of the *cirrus*, which loiters for hours, describing a little arc, and that of the *fracto-cumulus*, which has variable velocities. But after a few appearances of clouds with high velocity, the observer will be able to judge them correctly.

AZIMUTHAL ROTATION OF CLOUDS.

In a note presented to the French Meteorological Society, May 10th, 1864, I showed, from 280,320 observations made at the observatory of Havana, that the law of the rotation of winds formulated in 1827 by M. Dove is perfectly applicable to clouds, and it is this same rotary direction which determines the rotation of the inferior winds, and modifies all the meteorological phenomena; in a word, that meteorology must be taken *from above*, according to the profound remarks of M. Biot, at the French Academy of Sciences.

M. Dove's law of the change of winds may be thus recapitulated: 1. When in the northern hemisphere, currents of air coming from the equator, alternate with polar currents, the wind makes the tour of the compass oftenest in the order south, west, north, east, and south. 2. In the southern hemisphere it is the reverse, south, east, north, west, and south. 3. The influence of the wind upon meteorological phenomena, combined with this law of its change, shows two parts of the compass, opposed in all respects, the region of the east and that of the west, where the atmospheric variations offer a correspondence with the instruments, which it is easy to understand. We see, therefore, that this important law of M. Dove can assist us in *scientific prevision*, if we add M. Buys-Ballot's method of *ecarts*, which consists in taking the difference between the highest and lowest standing of the barometer, thermometer, &c.

Now, if the change of clouds, from *cirrus* to *fracto-cumulus*—that is to say, from an altitude of at least 10,000 meters to the surface of the earth—really obeys the same law as the change of winds, then our previsions acquire a greater degree of certainty.

In 1863 the wind at Havana completed twenty-three rotations, conjointly with *cumulus;* these latter, twenty-five rotations; *cirro-cumulus*

eighteen, and *cirrus*, seventeen. Two rotations, from 29th of June to 19th of October, were not accompanied with those of the wind.

Sometimes we find that all the strata of clouds, up to the *cirrus*, complete their rotation at the north on the same day and at the same hour. At other times, and these are the most numerous, the wind gains upon the *cumuli*, these on the *cirro-cumuli*, and these latter on *cirri;* that is to say, from below upward instead of from above downward, as before their rotation. This fact seems to contradict the hypothesis that the superior currents determine gradually the inferior currents. This, however, is owing to the fact that the currents are inclined, forming very nearly an angle of 45° with the surface of the earth, so that they are first felt at a point more to the north, falling by degrees until they attain all the points of their journey toward the south, through which they have passed above, till their extinction naturally, or by the shock of opposite currents. This appearance of the inferior current before the superior is especially frequent in low regions. It is presented five times against four between the wind and *cumulus*, and four other times simultaneously. In the higher regions, six times to five, the *cirro-cumulus* appeared before the *cirrus*, and in three other cases at the same time. The *cumuli*, in their turn, gained eleven times against two upon the *cirro-cumuli*, and twice again they happened at the same time.

By reason of the opposition or inversion of temperature between land and sea, the wind tends toward the south in the evening, and in the morning toward the north. The influence of these local movements of the breeze is such, in the general circulation, that it may retard the rotation of the wind, which terminates at the north, not only many hours, but besides from 90° to 180° in azimuth. The action of the sea-breeze seems to be more considerable than that of the land-breeze; but the breezes are much less sensible upon the *cumulus* and *cirro-cumulus*, especially when these latter are elevated, and they do not seem to reach the region of the *cirrus*. The continuance of each rotation varied considerably in 1863, as follows:

	Days.	Hrs.		Days.	Hrs.
For the *cirrus*, from	5	5	to	49	11
For the *cirro-cumulus*, from	3	8	to	62	5
For the *cumulus*, from	3	3	to	36	22
For the wind, from	4	0	to	71	9

The month of July did not present a single rotation of any of these four elements. It should be remarked that the greater number of the wind's rotations are accompanied by another rotation in the *cumulus;* that those of *cirro-cumulus* are more rare and less corresponding with the first; and that, in fine, those of *cirrus* are still further removed. It also appears that the rotations are less frequent in the higher regions than at the surface, and that the first of the *cirrus*, due to the equatorial current, are borne rather to the west, and especially to the southwest; while the second of the *cumulus*, arising from the polar current, are confined more to the region of the east, from north to southeast.

Whatever may be the regularity presented by the circulation of the winds, and of the clouds in the tropics, and whatever care, also, is taken in studying it, this circulation is not yet exempt from perturbations which mask a little the precise moment of the beginning and end of each rotation. The southeast trade-winds, and the configuration of the ground, are among the number of general disturbing causes; while the land and sea breezes, the cloudiness of the stratum of *cumulus*, which is more or less time prolonged, and covers that of *cirro-cumulus*, or these latter that of *cirrus*, their inclination in space, and consequently their transformation accidental and sudden, constitute the local disturbing causes.

I surmise, besides, the existence of great annual rotations produced by the earth's motion of translation in its orbit analogous to those produced by the rotation of the earth on its axis, both classes of rotation belonging to each climate of the terrestrial zones, having regard to the distribution of continents and seas, and to their physical constitution. These annual rotations appear to commence and terminate at the north; for the *cirrus* in October, for the *cirro-cumulus* in November, for the *cumulus* in December, and for the wind in January. According to this, the superior current employs a month in accomplishing its rotation from stratum to stratum, continually approaching the surface of the earth, and three months in reaching it.

Lieutenant Maury claims that the trade-winds are so *constant* and *uniform* that their direction no more changes than the current of the Mississippi. I do not share the opinion of this *savant*, for the observations at Havana demonstrate, on the contrary, that the north tradewind varies from northeast, and sometimes north-northeast, up to eastnortheast, chiefly from December to May, the time at which the current, from the northern hemisphere appears to be stronger than that from the southern, and consequently it approaches the equator. In the second part of the year, from June to November, the south polar current, being more intense, drives back the first, and advances to the latitude of Havana, and probably to the parallel of 30° north, the trade-wind then varying from east-northeast to southeast; so the limit of the displacement in latitude of the trade-winds depends more particularly on the respective intensity of the polar currents of each hemisphere. We see, therefore, that the time of appearance which I have established for *fracto-cumulus* and *cumulus* seems to correspond with the displacement of the trade-winds.

In fine, it is at the moment when the rotations of the wind and of *cumulus* correspond toward the southwest with that of the equatorial current that storms and great showers have generally taken place, in presence of a compact stratum, and a condensation of superior *pallio-cirrus*, and another stratum of inferior *pallio-cumulus*. But as soon as the wind and the *cumulus* revolve to the west, the storm begins to clear off, and the barometer rises. When these first two rotations terminate

at the north, the weather is completely reëstablished. The stratum of *pallio-cumulus* opens up, is broken, and continues thus to chase from the southwest; then it revolves, in turn, toward the north, in order, later, to commence a new rotation. The second stratum of superior *pallio-cirrus* proceeds in like manner, and disappears also.

Such are the principal facts concerning the azimuthal rotation of the winds and clouds, and, in general, of the diverse questions which have been treated in the course of these summary *instructions*, on which it is of the highest importance to fix the attention of observers in all parts of the world. Indications analogous to those which the observations made at the observatory of Havana have furnished us, should they be contradictory under identical latitudes, either by reason of the difference in longitude, or by the difference in the topography of the countries explored, will not be the less important on this account, and they will conduct us to a true conception of *atmospheric circulation* altogether, by putting us on the track of rational and scientific previsions.

ON THE EVAPORATION OBSERVED AT PALERMO IN 1865 AND 1866.

BY P. TACCHINI.

[*Translated for the Smithsonian Institution from the Meteorological Bulletin of the Royal Observatory of Palermo.*]

Evaporation is one of the most important elements bearing upon climatological relations, but one which, until now, has been little studied. In Italy there are some few stations in which such observations are conducted, although by different methods. In the determination of this element many difficulties and anomalies present themselves, insomuch that it is regarded as the least certain of all the problems offered by meteorology. Yet the instruments devised for the measurement of evaporation have been of late greatly improved, and in our opinion that of Vivenot is to be regarded as among the best. In our observatory the evaporation is observed simultaneously with two atmometers, one of which, being that of Gasparin, is entirely exposed to the direct action of the air and the solar rays; the other, that of Vivenot, is stationed with the other instruments of meteorology, designed for the temperature and humidity, that is to say, is defended from the direct action of the wind and sun. These two atmometers were described in our Bulletins Nos. 1 and 4 for 1865. The series of observations which we are about to present extends through twenty months, from May, 1865, when a commencement was made with the atmometer of Vivenot, to December, 1866, inclusive. This interval is undoubtedly too short for arriving at definitive conclusions; but on a comparative examination of the curves of evaporation with those of the other meteorological elements, we have always observed a constant relation, especially in regard to the temperature, force of the wind, and humidity, as may be verified by the monthly reviews. In consequence of this, I propose to determine these relations from the observations made, that is, to seek an expression for the evaporation in functions of those elements, whence a first approximation may be obtained, serving as a contribution on our part to the researches on the climate of Italy.

[We are unacquainted with the atmometer of Vivenot; that of Gasparin consists of a shallow vessel of tinned copper, one meter square, and fifty centimeters in depth. In one corner of this is a fine screw placed perpendicularly, with a micrometer head at the top, and a fine point at the bottom, by means of which a small fractional part of a millimeter of the depression of the surface of the water can be estimated. It is also furnished with a maximum and minimum thermometer, the bulbs of each being sheltered from the direct rays of the sun, while they partake of the temperature of the surface of the water. This apparatus is freely exposed to the open air and sunshine. Care is required that no water is allowed to fall into the vessel from rain, or if it does fall in, to allow for the quantity.—J. H.]

Table of the elements which have been employed in the researches on evaporation, as observed with the Vivenot atmometer, transcribed from the monthly bulletins.

Months.	Temperature.	Humidity.	Force of the wind.	Daily evaporation.	Total evaporation of the month.
1865.					
May	+20.5	68.9	7.4	3.394	105.215
June	23.5	63.5	11.2	4.719	141.581
July	26.0	64.3	9.7	5.113	159.082
August	26.7	64.7	6.9	5.268	164.008
September	23.4	67.3	9.2	4.329	128.921
October	20.3	75.5	10.9	2.746	85.132
November	15.9	69.0	9.0	2.790	83.730
December	12.3	73.3	8.0	2.151	66.688
1866.					
January	11.6	75.0	8.9	2.492	77.240
February	14.0	71.4	9.2	2.819	84.720
March	15.2	64.6	11.3	3.906	121.080
April	16.7	67.1	8.2	3.847	115.410
May	18.9	66.9	6.5	4.239	131.411
June	22.5	71.8	5.4	4.432	132.960
July	26.1	63.7	9.8	6.905	214.047
August	25.0	66.0	7.9	5.918	183.460
September	23.4	72.3	4.4	4.089	122.752
October	20.0	70.6	5.4	3.493	108.285
November	15.9	68.9	7.6	3.211	96.318
December	12.9	73.0	9.2	2.314	71.740

From the above table it will at once be perceived that the prime productive cause of evaporation is the temperature, the action of which may be promoted by the force of the wind and impeded by the humidity. If, therefore, we consider the quantity of evaporated water in relation alone to the temperature as the sole cause, we may deduce the equation—

$$390.8\ t = 78.175$$

whence—

$$t = +\ 0.20004$$

If then the heat alone were the evaporating force, by multiplying the mean daily temperature by the coefficient we should have the quantity of the evaporation in millimeters. By making this calculation for the months from the preceding table, and considering the differences between the observation and the calculation, it will be seen that, in 1865, the greatest differences are met with in the months of May and October, in which there occur two maxima of humidity, and that at that time the evaporation observed is less than that calculated; and, in 1866, the greatest differences are observed in the months of March, July, and August, in which there occur minima of humidity and an increase in the force of the wind, so that the observed evaporations become in these months greater than those calculated. Hence the influence of the force of the wind and of the humidity of the air is manifest. Taking account

then of the three elements, temperature, humidity, and force of the wind, we establish with the data of the table, for the daily evaporation, 20 equations of condition, which being resolved by the method of least squares yield the following normal equations:

$$\left.\begin{aligned} 8.10\,.\,t+26.78\,.\,h+\ \ 3.22\,.\,f-1.63&=0 \\ 26.78\,.\,t+95.93\,.\,h+11.45\,.\,f-5.33&=0 \\ 3.22\,.\,t+11.45\,.\,h+\ \ 1.45\,.\,f-0.65&=0 \end{aligned}\right\} \quad \text{- - - - - (1.)}$$

wherein t, h, f, are the coefficients of the temperature, humidity, and force of the wind, to be determined. The equations (1) being resolved, we obtain the following values:

$$t=+\ 0.20675$$
$$h=+\ 0.01517$$
$$f=+\ 0.11006$$

which coefficients indicate that with the increase of the temperature and force of the wind, the evaporation also augments, while it diminishes with the increase of the humidity, which, in effect, is also shown by the actual review of each month. The formula, then, of the evaporation, by the Vivenot atmometer placed in the shade and defended from the direct action of the wind, will be the folowing:

$$E=T\,.\,0.20675-H\,.\,0.01517+F\,.\,0.11006$$

in which T indicates the temperature in centesimal degrees, H the humidity in hundredths of saturation, F the horary velocity of the wind in kilometers. If, with this formula, we calculate the daily evaporation for each of the twenty months under consideration, we obtain the following figures, which we transcribe, beside those resulting from observation, with the relative differences:

Months.	Evaporation calculated.	Evaporation observed.	Difference.
1865.	*Millimeters.*	*Millimeters.*	*Millimeters.*
May	4.024	3.394	— 0.630
June	5.144	4.719	— 0.425
July	5.485	5.113	— 0.372
August	5.317	5.268	— 0.049
September	4.847	4.329	— 0.518
October	4.269	2.746	— 1.523
November	3.246	2.790	— 0.456
December	2.257	2.151	— 0.106
1866.			
January	2.255	2.492	+ 0.237
February	2.839	2.819	— 0.020
March	3.320	3.906	+ 0.586
April	3.374	3.847	+ 0.473
May	3.624	4.239	+ 0.615
June	4.177	4.432	+ 0.255
July	5.526	6.905	+ 1.370
August	5.054	5.918	+ 0.864
September	4.244	4.089	— 1.155
October	3.696	3.493	— 0.203
November	3.094	3.211	+ 0.117
December	2.574	2.314	— 0.260

Hence it would appear that if the daily evaporation be calculated in this way we incur the risk of an error of $\pm 0^{mm}.6$; and although this difference may seem considerable, yet, taking into account the small number of observations, and the anomalies which ordinarily occur in this element, as well as the excesses of the weather experienced in the two years of the observations, it will be seen that the variations in the evaporation are distinctly represented.

If the daily mean be thus calculated from the total of the twenty months, with $T = 19^{\circ}.54$, $H = 69.13$ and $F = 8.31$,

It will be found	=	$3^{m}.913$
And the mean of the observed evaporation		$3^{m}.924$
Difference	=	$0^{m}.011$

So that the total of the calculated evaporation for the twenty months is found	$=2386^{m}.93$
While that from observation	$2393^{m}.78$
Whence the difference	$=6^{m}.85$

As a proof of the manner in which this formula may represent the course of the daily evaporation, we have calculated it for each day of the month of October, 1866, selecting this month for its variety in the different elements, so that the evaporation does not proceed directly in accordance with any of the curves of these elements.

The sum of the daily evaporations calculated for every day of this month gives a total of	$113^{mm}.34$
While the observed amount was	$108^{mm}.29$
Whence results a difference only of	$5^{mm}.05$

And from the course of the evaporation we have constructed the curves of evaporation as observed and calculated, which will be found in the annexed table, and which clearly demonstrate their conformity; thus proving the distinct exactness of the formula and the excellence of the instrument in its sensibility to the variations of the different elements which concur in the production of evaporation.

It is not at present possible to establish the exact ratio of the evaporation in the different seasons and months, because the proper elements are wanting. In regard to the meteorological year 1865–'66, we have the evaporation distributed in the following manner:

	Millimeters.
Winter	228.65
Spring	367.90
Summer	530.47
Autumn	327.36

that is to say, least in winter, greatest in summer, nearly equal in spring and autumn, being more restricted in the latter season, for reasons which will be easily perceived from the following table:

Seasons.	Temperature.	Humidity.	Force of the wind.
Winter	12.7	74.6	8.7
Spring	17.0	66.2	8.7
Summer	24.5	67.2	7.7
Autumn	19.8	70.6	5.8

For a first approximation, therefore, we may calculate the mean daily, monthly, and annual evaporation, as well as that for the seasons, by employing the coefficient only of the temperature, $t = 0.20675$. Thus, taking the mean monthly temperature derived from the observations of seventy-six years, we form the following table:

Months.	Mean temperature.	Daily evaporation as calculated.	Monthly evaporation as calculated.	Mean quantity of rain as observed.
		Millimeters.	*Millimeters.*	*Millimeters.*
January	+10.98	2.270	70.37	71.74
February	11.15	2.305	65.12	63.55
March	12.42	2.567	79.59	72.69
April	14.86	3.072	92.16	42.65
May	18.59	3.843	119.13	26.60
June	22.34	4.619	138.57	17.21
July	25.04	5.176	160.46	5.80
August	25.22	5.214	161.64	9.11
September	22.98	4.751	142.53	51.88
October	19.68	4.068	126.11	71.65
November	15.57	3.218	96.54	72.28
December	12.30	2.544	78.86	83.80

Hence, as regards seasons, the evaporation results as follows:

	Millimeters.
Winter	214.35
Spring	290.87
Summer	460.67
Autumn	365.18
Annual mean	1331.07

In regard to the water which fell, it will be seen that *in the months of January, February, March, and December, the evaporation was nearly equal; and that the annual evaporation was equal to twice and one-fourth the quantity of rain.*

THE GASPARIN EVAPORATOR.—With this atmometer the inconvenience constantly presents itself that, on days of rain, the indications point to erroneous results, through the impossibility of applying the

just correction for the water which falls, especially when there are very light showers, which cannot be measured by the pluviometer; whence the evaporation given by the Gasparin atmometer during the months when there has been rain will be always inferior to the reality. To have, therefore, the true ratio between the indications of the two atmometers, and to correct those of the Gasparin instrument, we proceed in the following manner: From the sums of evaporation, given by the two instruments in days when there was no rain, is deduced the ratio between the two evaporations for each month, and from the evaporation observed with the atmometer of Vivenot, on the days of rain, is derived, by means of the ratio, the corrections to be made in the indications of that of Gasparin.

In the following table will be found the monthly sums of this atmometer thus corrected, and which differ from those given in the single bulletins, because the aforesaid correction is then not applied. Hence, to determine a formula representing the evaporation according to the Gasparin atmometer, it is to be remembered that in this instrument the action of the force of the wind must needs be greater than for that of Vivenot, and that it is necessary, moreover, to take into account the direct action of the solar rays, as we have not the temperature of the water by that atmometer. We will suppose this action of the solar rays proportional to the sine of the meridian altitude of the sun, for the effect of the solar rays may be modified by the presence of clouds, diminishing that action whenever they interpose between the sun and station. On the other hand, the action of the daily temperature and the humidity will, for this instrument, be the same as for that of Vivenot; whence the coefficients relative to these two elements will remain the same. If, then, we calculate the part of the evaporation due to these two elements and subtract it from the daily evaporation of the Gasparin atmometer, the remainders of evaporation will be due to the direct action of the solar rays, the direct action of the wind, and the serenity. With these remainders will be established the equations of condition from which are to be found the coefficients, a, v, and f, relative to the sine of the meridian altitude of the sun, the serenity, and force of the wind.

In the table which follows will be found united all the necessary elements, that is to say, the mean value of the sine of the sun's altitude for every month, which we will denote by *sine* h, the volume of the clouds, the force of the wind, daily evaporation of the Gasparin instrument, the total for every month, by both the atmometers, and their relation; finally, the remainders of that of Gasparin, calculated as has been above stated.

Months.	Sin h.	Volume of clouds.	Force of wind.	Daily evaporation.	Total in the month.	Total evaporation, Vivenot.	Difference, G−V.	r
1865.				*Millimeters.*	*Millimeters.*	*Millimeters.*	*Millimeters.*	*Millimeters.*
May	0.945	38	7.4	5.753	178.33	105.21	1.695	2.528
June	0.967	28	11.2	7.074	212.21	141.58	1.313	3.145
July	0.958	15	9.7	7.977	247.30	159.08	1.554	3.538
August	0.911	11	6.9	7.490	232.18	164.01	1.416	2.913
September	0.816	24	9.2	6.002	180.06	128.92	1.397	2.149
October	0.682	50	10.9	3.524	109.32	85.13	1.284	0.439
November	0.548	55	9.0	2.751	82.54	83.73	0.986	0.482
December	0.478	61	8.0	1.928	59.78	66.69	0.896	0.531
1866.								
January	0.515	53	8.9	2.209	68.46	77.24	0.886	0.924
February	0.630	36	9.2	3.159	88.46	84.72	1.044	1.321
March	0.768	49	11.3	4.974	154.19	121.08	1.274	2.785
April	0.882	34	8.2	5.833	175.00	115.41	1.516	3.371
May	0.945	43	6.5	5.568	172.61	131.41	1.313	2.648
June	0.967	27	5.4	6.232	186.95	132.96	1.406	2.634
July	0.958	6	9.8	8.911	276.24	214.05	1.291	4.442
August	0.911	17	7.9	7.547	233.97	183.46	1.275	3.342
September	0.816	30	4.4	5.002	150.05	122.75	1.222	1.223
October	0.682	46	5.4	3.236	100.32	108.29	1.926	0.139
November	0.548	38	7.6	2.863	85.89	96.32	0.892	0.593
December	0.478	43	9.2	2.495	77.35	71.74	1.078	0.931

With the numbers of the 1st, 2d, 3d, and last columns are, formed twenty equations, which, treated by the method of least squares, yield the three following equations:

$$\left.\begin{array}{r} 12.50\,.\,a+\ \ 503.18\,.\,v+\ 117.15\,.\,f-\ \ 34.75=0 \\ 503.18\,.\,a+29270.00\,.\,v+5883.60\,.\,f-1117.61=0 \\ 117.15\,.\,a+\ 5883.60\,.\,v+1449.90\,.\,f-\ 341.62=0 \end{array}\right\} \quad \text{- - -} \quad (2)$$

These equations (2) being resolved, we find—

$$a=+2.9227;\ v=-0.0651;\ f=+0.2642$$

The signs of these coefficients agree with the considerations before stated, and the value of f, coefficient of the force of the wind, gives a result more than double that determined by the Vivenot atmometer, as we had supposed would be the case in the independent description of that instrument.

The daily evaporation of the Gasparin atmometer, indicated by E′, would be represented by the formula—

$$E'=T\,.\,0.20675-H\,.\,0.01517+F\,.\,0.2642-V\,.\,0.0651+(\sin h)\,.\,2.9227$$

where T is the daily mean temperature, H the humidity, F the force of the wind, V the quantity of the clouds expressed in hundredths of the sky obscured, and sin h the sine of the meridian-altitude of the sun. Calculated by this formula, we obtain the following results for the daily evaporations, which in the annexed table are placed beside those observed, as well as their relative differences:

Month.	1865.			1866.		
	Calculated.	Observed.	O—C.	Calculated.	Observed.	O—C.
	Millimeters.	*Millimeters.*	*Millimeters.*	*Millimeters.*	*Millimeters.*	*Millimeters.*
January	....	....	....	1.689	2.209	+0.520
February	....	....	....	3.766	3.159	−0.607
March	....	....	....	4.327	4.974	+0.647
April	....	....	....	4.992	5.833	+0.841
May	5.466	5.753	+0.287	4.599	5.568	+0.969
June	7.890	7.074	−0.816	6.093	6.232	+0.139
July	8.823	7.977	−0.846	9.465	8.911	−0.554
August	8.345	7.490	−0.855	7.846	7.547	−0.299
September	7.105	6.002	−1.103	5.373	5.002	−0.371
October	4.701	3.524	−1.177	3.521	3.236	−0.285
November	2.666	2.751	+0.085	3.404	2.863	−0.541
December	0.935	1.928	+0.993	2.591	2.495	−0.096

From the differences it is seen that the results obtained by this instrument also are sufficiently exact to be capable of being approximately represented with the special formula, and the accord between the calculation and the observation seems to us satisfactory, regard being had to the construction and conditions of situation of this apparatus.

The daily mean thus calculated from the elements of the twenty months gives a result equal to $5^{mm}.156$, while the observed mean was $5^{mm}.027$; whence we have the difference, $0^{mm}.129$, so that the total evaporation as calculated for the twenty months is found to be equal to $3{,}145^{mm}.16$, and the sum of the evaporation observed $3{,}071^{mm}.21$—difference, $73^{mm}.95$.

The daily mean, as calculated for 1866, gives a result of $4^{mm}.7852$, and the total in the twelve months, $1{,}746^{mm}.60$, while the observed was $1{,}769^{mm}.49$—difference, $22^{mm}.89$.

Knowing, therefore, the mean force of the wind, the mean humidity, and at the same time the clearness and temperature, we shall be in a position to verify approximately the mean monthly and annual evaporation by this atmometer exposed to the direct action of the wind and rays of the sun. We have not all these elements, and hence cannot at present apply the formula in its entirety. But, for a first approximation, we may take account solely of the temperature, humidity, and altitude of the sun, having the coefficients of the force of the wind and volume of the clouds contrary signs; in effect, thus calculated the evaporation for 1866 results differently from that observed, which was $1{,}769^{mm}.0$ by only $56^{mm}.0$.

By making the calculation, with the relative humidity transcribed from the only decennium in which psychrometrical observations were conducted, the evaporation in the open air yields the results denoted in the following table, as well for the daily mean as for the total of each month and each season, together with the annual mean:

Months.	Mean temperature.	Mean humidity.	Sin h.	Daily evaporation.	Monthly evaporation.	By seasons.	
January	+10.98	78.7	0.515	2.595	80.45	Winter	249.32
February	11.15	77.7	0.630	2.982	84.24		
March	12.42	77.2	0.768	3.654	113.27		
April	14.86	76.1	0.882	4.508	135.24	Spring	419.07
May	18.59	73.5	0.945	5.502	170.56		
June	22.34	72.0	0.967	6.366	190.98		
July	25.04	70.1	0.958	6.925	114.68	Summer	617.64
August	25.22	69.3	0.911	6.838	211.98		
September	22.98	73.5	0.816	6.034	181.02		
October	19.68	75.7	0.682	4.926	152.71	Autumn	444.19
November	15.57	75.9	0.548	3.682	110.46		
December	12.30	80.7	0.478	2.730	84.63	Annual mean	1,730.22

In relation to rain, by comparing the total monthly evaporations with the mean quantity of water which falls in each month, and which will be found recorded in one of the preceding tables, it will be seen that the *evaporation according to the Gasparin apparatus is about equal to the rain only in the months of January and December, being always greater in the other months; the annual evaporation is very nearly thrice the height of the water which falls, and equal to once and a third of that in the shade, or as denoted by the atmometer of Vivenot.* From the quantities of the monthly evaporation calculated after both instruments let us take the differences referable to the different positions of the atmometers, and transcribe them in connection with those actually verified in 1866. G—V indicates the Gasparin evaporation less that of the Vivenot atmometer.

Differences.

	G—V from calculation.	G—V observed in 1866.
	Millimeters.	Millimeters.
January	+10.08	− 8.78
February	+19.12	+ 3.74
March	+33.69	+33.11
April	+43.08	+59.59
May	+51.43	+41.20
June	+52.41	+53.99
July	+54.22	+62.19
August	+50.34	+50.51
September	+38.49	+27.30
October	+26.60	− 7.97
November	+13.92	−10.43
December	+ 5.77	+ 5.61

The above differences, if we consider the disturbances to which the Gasparin atmometer is exposed from rain and clouds, discover a suffi-

cient agreement, and at the same time show that these differences increase from January till the month of July, and then diminish until December, in which occurs the minimum of difference for the two instruments.

In calculating the evaporation by day and that by night for each month, we have found the following numbers:

Months.	Evaporation.		
	By day.	By night.	Ratio.
	Millimeters.	Millimeters.	Millimeters.
January	1.96	0.64	3.06
February	2.35	0.63	3.73
March	2.95	0.70	4.21
April	3.64	0.87	4.18
May	4.38	1.12	3.91
June	4.99	1.38	3.62
July	5.30	1.63	3.25
August	5.02	1.82	2.76
September	4.27	1.76	2.43
October	3.26	1.67	1.95
November	2.48	1.20	2.07
December	1.93	0.80	2.41

Thus the greatest evaporation at night occurs in the month of August, the least in February; the ratio between that of day and night increases from October to March, and then diminishes gradually till October.

From what we have thus been able to compile it would evidently seem that for a complete study of the subject of evaporation it is indispensable to have two atmometers, one to be stationed with the other meteorological instruments, and defended from the direct action of the wind and rays of the sun, the other entirely free. For the latter purpose the construction of the Gasparin atmometer is suited, for the former that of Vivenot, though it might be expedient to give to this last greater dimensions than those heretofore employed.

ON THE ELECTRICITY OF INDUCTION IN THE AERIAL STRATA OF THE ATMOSPHERE WHICH, IN THE SHAPE OF A RING, SURROUND A CLOUD THAT IS RESOLVING INTO RAIN, SNOW, OR HAIL.

By Professor Fr. Zantedeschi,
Of the Royal Venetian Institute of Sciences, Letters and Arts.

[Extracted from Vol. XII, series III, of the Transactions of the Institute.]

Professor Luigi Palmieri states as follows:

"Where rain is falling there must be present positive electricity, with a zone or wave of negative electricity on every side, which zone, in tempestuous weather, may extend to a distance of thirty miles, especially in summer. Upon this subject, after so many observations, conducted by

precise methods and under favorable circumstances, I feel at liberty to deny the free negative electricity of a serene sky, and also the existence of clouds endowed, as a property, with this electricity, maintaining that the negative electricity only manifests itself with the falling of the rain, hail, or snow, through the effect of the influence of the positive electricity, which is copiously developed on the resolution of the clouds into water. I deem it useless to explain how negative electricity may also be present when rain falls on the place of the observations, for this indicates another more intense rain which is proceeding at a certain distance."*

The Rev. Padre A. Secchi shows that he holds the same doctrine, for he says:

"In regard to the fact asserted by Professor Palmieri that negative electricity is not present in a serene state of the sky, except in the case of rain actually falling on the spot, or at least at some distance off and in view of the horizon, I have found it to be constantly verified."

He also recognizes a primary negative zone, which attends a storm through the effect of induction.†

The opinion of Professor Palmieri, thus sustained by Rev. Padre A. Secchi, is wanting in point of positive proof. It would be necessary, in order to supply such proof, that an experimenter should be stationed at the center where the cloud which is being resolved into rain is directly superincumbent, and should investigate the kind of electricity of the falling shower; while other experimenters should be placed around its periphery, so as to form a ring, each of whom should explore the nature of the electricity of the air surrounding the dissolving cloud. By a complete experiment like this, the problem propounded by Professor Palmieri might be solved. The rain falling at the center, endued with positive electricity or with negative electricity, should be found to have around it a circle of negative electricity or of positive electricity.

I requested Padre A. Secchi to make this experiment in the environs of Rome, but he assured me that it could not be carried into effect there on account of the topographic difficulties of the hills which encompass that city. Not being myself able to prosecute the experiment on a large scale in the Euganean region and the circumjacent cities of Vicenza, Lignano, Badia, Rovigo, and Padua, I limited my views to a cabinet experiment, which, nevertheless, appears to me sufficient for the solution of the proposed problem. I suspended to a thread of silk a hollow sphere of brass, which I proceeded to electrify now positively and again negatively. Arranging around it the wire of a straw electrometer and bringing it successively nearer to the electrified sphere, I

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* *Bolletino meteorologico dell' Osservatorio del Collegio Romano*, Vol. II, No. 15, p. 113, for the year 1863: Letter from Signor L. Palmieri, director of the *Osservatorio Vesuviano*, to Padre A. Secchi.

† *Bolletino meteorologico dell' Osservatorio del Collegio Romano*, Vol. II, No. 17, p. 129, for 1863: Reflections of Professor Francesco Zantedeschi on the article of Padre A, Secchi, entitled: *Altic studii di elettricita atmospherica*.

closed it at the distance at which the straws began to diverge. I now tested with an essayer the nature of the electricity of the electrometer. I found that if the electrified sphere was positive, the electricity of the electrometer was also positive; but if the sphere was electrified negatively, such also was the electricity of the electrometer. From this extreme point, on carrying the electrometer toward the sphere, I saw the tension always continue to increase without any change occurring in the species of electricity. An electrified solid then has around it an electric atmosphere of the same name. We should not confound, therefore, the distribution of the electricity presented by an isolated solid conductor at its surface, submitted to the influence of an electrified body, with the distribution of the electricity presented by the ethereal space surrounding that electrified body. This difference I demonstrated in all its particulars and circumstances in my memoir entitled "New experiments regarding the origin of atmospheric electricity and the electrostatic induction of the isolated solid conductors of Zantedeschi."*

I arrived at the same result by causing an artificial shower to fall from a certain height, which shower I electrified positively and negatively in succession, by means of my electrical machine, for the two electricities. The electrometer placed at a distance from the falling rain, which scarcely gave signs of tension, and which was next advanced to the place where it was raining, manifested an increasing tension, without yielding any signs of a changed electricity.

The following is a description of the experiment: A car was constructed with four wheels, which moved upon two threads stretched horizontally like the two lines of a railroad. The wheels as well as the threads were of gum-elastic, in order perfectly to isolate the car suspended by bodies commonly recognized as conductors. The vertical walls of the car and the horizontal floor were formed of conducting substances, but the floor was perforated throughout in order to give passage to a kind of artificial rain, when the cavity of the car was filled with water. At one end the floor of the car communicated by means of a conducting-wire with the electric machine, which, when charged positively, electrified positively the isolated car with the water which it contained, and, charged negatively, charged with negative electricity the aforesaid car and the water contained in it. Examining with an electrometer the kind of electricity of the falling rain, I have found that it was of the same nature with that of the electric machine, that is to say, positive if I had used the positive electricity of the machine, and negative if I had employed its negative electricity. Having assured myself of this result, I proceeded by means of an isolating thread of silk or gum-lac attached to the other end of the floor to bring the hydrometeoric electrical car into the proximity of a straw-electrometer. These straws always diverged more in proportion as the distance from the falling rain diminished, without, however,

* *Ateneo Italiano*, Vol. II, p. 339, printed at Paris by Victor Masson, 1854, and at Venice by G. Antonelli, 1854.

changing the kind of electricity. There must, of course, be the zero of tension, which occurs in solid and isolated conductors submitted to the electricity of influence, as it is now commonly termed in the schools, and I should say this zero of tension was immersed in the ethereal space electrified with the same electricity with which the body existing at the center was invested. I invite physicists to repeat my experiments, since by them may be overthrown the doctrine of atmospheric electricity of influence in the air; and, still more, the law, enunciated by Signor Luigi Palmieri, and confirmed by Padre A. Secchi, regarding the negative circle which surrounds the cloud that is being resolved into rain, snow, or hail.

ON THE PRESENCE OF ELECTRICITY DURING THE FALL OF RAIN.

BY PROF. PALMIERI, OF THE VESUVIUS OBSERVATORY.

[*Translated for the Smithsonian Institution.*]

All the observations upon atmospherical electricity made during storms before 1850, the date of my first memoir upon electrical meteorology, had established the presence of electricity of greater or less tensions—alternately positive and negative—and consequently neutral during its passage from one phase to the other. During the fall of rain in calm weather electricity had been observed to be sometimes positive, sometimes negative; and many authors, as Kämtz, were induced to distinguish *positive* and *negative* rains. Quetelet alone had observed that during the same fall of rain there might be positive and also negative electricity. During this confusion I found, in 1853, a very simple law that determines electrical manifestations during the fall of rain, hail, or snow; having been enabled to discover it, thanks to a movable conductor and to the possibility of placing it on the Vesuvius Observatory, 637 meters above the level of the sea, and under the clear atmosphere of Naples, through which objects can be seen at a great distance. This law can be expressed thus: *When rain falls there is a considerable development of positive electricity, with a zone or wave of negative electricity, followed by another of strongly positive electricity.*

The breadth of the zones depends upon the extensiveness of the showers, and also upon the conditions of the air surrounding the clouds that resolve themselves into water. The course followed by the rain while falling through a more or less extensive space, according to the direction of winds, gives the observer an opportunity to note the passage from one phase to another; and if rain was falling on a given point with the same intensity, and without change of direction, the observer would have continually the same phase. The breadth of the zones alters rapidly during the appearance of lightning, and then soon returns to its previous state. Any variation in the intensity and extensiveness of the showers causes changes in the breadth of the zones, and therefore the observer is easily

enabled by all those causes to note the passage from one phase to the other. Such is the origin of every phenomenon previously observed. After having established this law by many personal observations, I did not fail to seek for its corroboration in the records of the observations of others; and many facts mentioned by Beccaria seemed to me derived from that law, which is otherwise corroborated in a description of a fall of hail observed by Oward. Quetelet, upon hearing of this law, examined the records of his own observations, and found it corroborated by them; and he then proclaimed it also, taking my observations into account, but not giving me clearly the priority of discovery that undoubtedly belonged to me. Afterward others confirmed said law, which I never failed to verify whenever opportunity offered, the best conditions being to have a very extensive horizon and a rain or storm commencing at a considerable distance from the observer, approaching him with the wind, and then leaving him behind. These are, in fact, the only conditions in which it is possible to verify the truth of the above-mentioned law.

On the 20th of September, 1868, on or about 11 o'clock a. m., there appeared above the sea, in a westerly direction, somewhere beyond the Ponzie Islands, a cloud of very small dimensions. Suspecting a storm, I used the apparatus with movable conductor, and noticed a strongly positive tension, indicating a distant rain; and suspending the conductor in an elevated position, the oscillations of the gold plates of Bohnenberger's electroscope indicated lightning. The wind was very weak and coming from southwest, bringing the storm toward the observatory.

At noon the tension became negative, and after a few moments, during which it was null, and when already could be heard the thunder-claps of the approaching storm, the negative tension increased so as to emit sparks; thunder was heard more distinctly, and rain was seen falling on the Campania. At 1 o'clock p. m. rain was falling upon the observatory, and the tension, passing through 0, became positive. At 3 p. m. rain had ceased to fall on the observatory, but was falling over Castellamare, giving again a strong negative tension. Over the Mounts of Castellamare it ceased to rain, and positive electricity returned, but with a weak tension of 15°. Had the storm kept on its primary course east of the observatory, there should have been a strong positive tension ($+\infty$). In this case, therefore, the last phase alone failed to be observed.

Whoever found himself in elevated places, or upon the open sea, must have often noticed two or more rains, each distinct from the other, falling with small intervals between them; and this explains why apparent exceptions are often recorded against the universality of the law. Let us suppose, for instance, that on the spot where is the observer a rain is falling, while another, stronger, falls at some distance; then it becomes evident that, if positive and negative electricity were to be obtained from the first stronger than from the second, with the rain falling upon the observatory, there should be in it negative electricity. And this is

the origin of the assumed negative rains, as well as of the supposed negative clouds, two errors as yet taught by some authorities. After twenty years of study of electrical meteorology, I believe I have acquired the right to reject many errors, without caring about the names of those by whom those errors were accredited. But, giving a proper interpretation to the facts recorded by diligent and eminent observers, instead of objections to the truth of the principle I have exposed, we discover in them the proof of what I have said. Many, for instance, upon the authority of Beccaria, affirm the production of electricity in pure atmosphere, (*ciel sereno*,) and I have demonstrated that this can only take place when, at some distance from the place of observation, rain, hail, or snow is falling. Now, by a careful perusal of the illustrious electrician's works, we see that, instead of a refutation of my principle, there is in them what might entitle him to the right of priority in the discovery. The following passage from Beccaria's works seems quite clear: "*Electricity in pure atmosphere is always in excess, and whenever in serene atmosphere electricity in defect is observed, it has been carried there by wind from some part of the atmosphere, as distant as it might be, where there are actually clouds, snow, rain, or hail.*" It is evident that the diligent observer derives the electricity in such case from a distant region, not serene, and, instead of the influx, believes it to be carried by the wind; but the fact of electricity becoming negative after the storm had passed the place of observation, and was carried eastward by a gentle wind, as previously described, would be sufficient to preclude the idea of the wind as carrier of negative electricity, even had I not observed, a hundred times, electricity with the most perfect calm. Suppressing, therefore, the word cloud in Beccaria's sentence above reproduced, it will remain a fact that negative electricity in serene atmosphere is obtained only when, at a distance from the place of observation, rain, hail, or snow is falling.

Peltier had observed negative electricity in presence of certain clouds of a dark-bluish color, and thought that their electrical nature might be made known by their color. When clouds at a distance resolve themselves in rain they exactly assume that color described by the French physicist, and the falling rain produces negative electricity. Thus my observations are confirmed, not refuted.

The existence of clouds loaded with negative electricity pertaining to them has been attributed either to the negative electricity often observed with a fall of rain at the place of observation, or to the same electricity observed in presence of clouds. We have explained how the first is produced; the second is a certain sign of distant rain. On the Vesuvius Observatory clouds often pass in such a way as to surround the whole building; yet in many years of continued observations, with fixed and movable conductors, I have never met, under those conditions, with negative electricity.

CLIMATE OF KANSAS.

By R. S. Elliott,
Industrial agent Kansas Pacific Railway.

Pond Creek Station, Kansas Pacific Railway,
September 22, 1870.

I have been on the Plains nearly all the time from early in May till this date. There has been much dry weather, but I have not seen one cloudless day; no day on which the sun would rise clear and roll along a canopy of brass to the west. There has always been humidity enough to form clouds at the proper height, and on many days they would be seen defining, by thin flat bottoms, the exact line where the condensation became sufficient to render the vapor visible. The sun would be only partially obscured at intervals, the condensation not being of a character materially to lessen the effect of his rays in giving us heat and light, until in the after part of the day, when appearances of a storm were apt to present themselves in some part of the heavens; only, however, too often to pass away without giving us the desired shower.

I conclude from all this that abundant moisture has floated over the Plains to have given us a great deal more rain than would be desirable if it had been precipitated.

Sometimes a storm would be seen to gather near the horizon, and we could see the rain pending from the clouds like a fringe, hanging apparently in mid-air, unable to reach the expectant earth. The rain stage of condensation had been reached above, but the descending shower was revaporized apparently, and thus arrested.

In a moderately calm day—for our calms are only *moderate* in this airy region—I have observed little columns of dust to arise in all directions, generally widely scattered. These usually, if not always, coincided with mirage in all directions; not that they appeared in the mirage, but coincided in the day of their appearance. The mirage, however, very often appeared on days too windy for the little columns to be formed; they being only whirlwinds rendered visible by the dust taken up. Within forty-eight hours after the little column phenomena, I have noted that the wind is apt to be coming strongly from the northward, laden with a mist or scud that sometimes reaches the dignity of rain.

The changes of wind are often very sudden, from southward—the prevailing point in summer—to all points, but mainly to the north. Sometimes this change is observed during the progress of a rain-storm, and *seems* to be due to a sort of local or limited cyclone; but the difference in temperature between the south and north winds seems to forbid the cyclone theory. I cannot understand how a circuit of a few hundred miles in the heated prairie should so cool a current that had only

whirled by us a very short time before. If we reject the cyclone theory we must suppose parallel but opposite currents, in streaks, thus:

On 15th July last I witnessed a fine example of this sudden change of direction and temperature in the wind. A storm arose, with lightning in the west, the southwest, and the northwest. The railway train was going eastward at the distance of about three hundred and twenty-five miles west from Kansas City. We were soon enveloped in the storm, rain, and wind so strong from the north that the wheels of the coaches could be felt grating their flanges on the south rail, and the rain, striking the end windows of the car, ran across in a true horizontal line. In a few minutes the temperature had fallen so low as to be uncomfortable; but in a run of not, I think, over ten miles, we were again in the *warm* winds usual at that season, and these, by contrast, seemed to be the *hot* winds sometimes experienced.

These hot winds are not, so far as I have observed, apt to be constant in one place for any considerable length of time; they strike your face suddenly, and in perhaps a minute are gone. They seem to run along in streaks, or *ovenfulls*, with the winds of ordinary (but rather high) temperature. They do not begin, I believe, till in July, as a general rule, and are over by September 1, or perhaps by August 15. Their origin I take to be, of course, in heated regions south or southwest of us; but their peculiar occurrence, so capricious and often so brief, I cannot explain to myself satisfactorily.

I have no rain-gauge record at hand for this and past seasons; but I may remark that this season, since about 15th of July, in these distant plains, has given us rain enough to make beautifully verdant the spots in the prairie burned off during the "heated term" of July. From Kit Carson eastward the rains have been, I think, exceptionally abundant. All through the summer we have had dew occasionally; and it has been remarked that buffalo meat has been more difficult of preservation than heretofore; facts indicative of humidity in the atmosphere, even when but little rain-fall was witnessed. Turnips sown in August would have made a crop, without irrigation, in this vicinity, four hundred and twenty-two miles west of the State line of Missouri, and about three thousand two hundred feet above the sea-level.

Facts such as these seem to sustain the popular persuasion in Kansas, that a climatic change is taking place, promoted by the spread of settlements westwardly; breaking up portions of the prairie-soil; covering the earth with plants that shade the ground more than the short grasses,

thus checking or modifying the reflection of heat from the earth's surface, &c. The fact is also noted that even where the prairie soil is not disturbed, the short buffalo-grass disappears as the "frontier" extends westward, and its place is taken by grasses and other herbage of taller growth. That this change of the clothing of the Plains, if sufficiently extensive, might have a modifying influence on the climate, I do not doubt; but whether the change has been already spread over a large enough area, and whether our apparently or really wetter seasons may not be only part of a cycle, are unsettled questions.

The civil engineers of this railway believe that the rains and humidity of the Plains have increased during the extension of the railroads and telegraphs across them. If this is the case, it may be that the mysterious electrical influence in which they seem to have faith, but do not profess to explain, has exercised a beneficial influence. What effect, if any, the digging and grading, the iron rails, the tension of steam in locomotives, the friction of metallic surfaces, the poles and wires, the action of batteries, &c., could possibly or probably have on the electrical conditions, as connected with the phenomena of precipitation, I do not, of course, undertake to say. It may be that wet seasons have merely happened to coincide with railroads and telegraphs. It is to be observed that the poles of the telegraph are quite frequently destroyed by lightning; and it is probable that the lightning thus discharges in many places where before the erection of the telegraph it was not apt to do so, and perhaps would not reach the earth at all.

I trespass on your attention with these crude remarks, not knowing but what I might possibly lead your thought to something of value in connection with meteorological phenomena in this distant but interesting region. You will readily see that I have no claim to the possession of meteorological knowledge, in the higher sense of the term.

I may state that during the past season, from April to July, wheat was grown and matured, *without irrigation*, at a point on the Plains three hundred and seventy-six miles west of Kansas City, and two thousand nine hundred and forty-eight feet above the sea. A sample has been sent to the Department of Agriculture. This wheat, about meridian 101, sustains the views of the article I took the liberty of sending you in March last on the "Climate of the Plains."

ACCOUNT OF A HAIL-STORM ON THE BOSPHORUS.

From Porter's (Commodore) Constantinople, 1835, *Vol. I, pp.* 43–47.

[Our attention has been called to the following account of a remarkable hail-storm, published in the letters of the late Commodore Porter, of the United States Navy, a work now out of print and not likely to meet the eye of meteorologists.—J. H.]

On our way from the residence of the minister to meet the Reis Effendi, at Candalie, half way between this and Constantinople, and a few minutes after leaving the landing, I witnessed a scene the most awful and appalling that the imagination can depict.

In a six-oared kaick, the American minister, his secretary, &c., and myself, with his kervoss, started with the treaty and regalia of about thirty thousand dollars worth of snuff-boxes, which you might have put in your coat pocket. We had got perhaps a mile and a half on our way, when a cloud rising in the west gave indication of an approaching rain. In a few minutes we discovered something falling from the heavens with a heavy splash, and of a whitish appearance. I could not conceive what it was, but observing some gulls near, I supposed them to be darting for fish; but soon after discovered that they were large balls of ice falling. Immediately we heard a sound like rumbling thunder, or ten thousand carriages rolling furiously over the pavement. The whole Bosphorus was in a foam, as though heaven's artillery had been discharged upon us and our frail machine. Our fate seemed inevitable; our umbrellas were raised to protect us; the lumps of ice stripped them into ribands. We fortunately had a bullock's hide in the boat, under which we crawled and saved ourselves from further injury. One man, of the three oarsmen, had his hand literally smashed; another much injured in the shoulder; Mr. H. received a severe blow in the leg; my right hand was somewhat disabled, and all more or less injured.

A smaller kaick accompanied, with my two servants. They were both disabled, and are now in bed with their wounds; the kaick was terribly bruised. It was the most awful and terrific scene that I ever witnessed, and God forbid that I should ever be exposed to such another. Balls of ice as large as my two fists fell into the boat, and some of them came with such violence as certainly to have broken an arm or a leg, had they struck us in those parts. One of them struck the blade of an oar and split it. The scene lasted, may be, five minutes; but it was five minutes of the most awful feeling that I ever experienced. When it passed over we found the surrounding hills covered with masses of ice, I cannot call it hail; the trees stripped of their leaves and limbs,

and everything looking desolate. We proceeded on our course, however, and arrived at our destination drenched and awe-struck. The ruin had not extended so far as Candalie, and it was difficult to make them comprehend the cause of the nervous and agitated condition in which we arrived; the Reis Effendi asked me if I was ever so agitated when in action? I answered no, for then I had something to excite me, and human means only to oppose. He asked the minister if he was ever so affected in a gale of wind at sea. He answered no, for then he could exercise his skill to disarm or render harmless the elements. He asked him why he should be so affected now. He replied, "From the awful idea of being crushed to death by the hand of God with stones from heaven, when resistance would be vain, and when it would be impious to be brave." He clasped his hands, raised his eyes to heaven, and exclaimed, "God is great!"

Up to this hour, late in the afternoon, I have not recovered my composure; my nerves are so affected as scarcely to be able to hold my pen or communicate my ideas. The scene was awful beyond all description. I have witnessed repeated earthquakes, the lightning has played, as it. were, about my head; the wind roared, and the waves have at one moment thrown me to the sky, and the next have sunk me into a deep abyss. I have been in action, and have seen death and destruction around me in every shape of horror; but I never before had the feeling of awe which seized upon me on this occasion, and still haunts, and I feel will ever haunt me. I returned to the beautiful village of Buyucdenè. The sun was out in all its splendor; at a distance all looked smiling and charming, but a nearer approach discovered roofs covered with workmen repairing the broken tiles; desolate vineyards, and shattered windows. My porter, the boldest of my family, who had ventured an instant from the door, had been knocked down by a hailstone, and had they not dragged him in by the heels would have been battered to death. Of a flock of geese in front of our house, six were killed, and the rest dreadfully mangled. Two boatmen were killed in the upper part of the village, and I have heard of broken bones in abundance. Many of the thick brick tiles with which my roof is covered are smashed to atoms, and my house was inundated by the rain that succeeded this visitation. It is impossible to convey an idea of what it was. Imagine to yourself, however, the heavens suddenly frozen over, and as suddenly broken to pieces in irregular masses, of from half a pound to a pound weight, and precipitated to the earth. My own servants weighed several pieces of three-quarters of a pound, and many were found by others of upward of a pound. There were many which fell around the boat in which I was that appeared to me to be as large as the swell of the large-sized water decanter. I have heard of a stout tree in my neighborhood, into the crotch of which a mass of ice fell which split the tree as though it had been riven by a wedge of iron.

ACCOUNT OF A HAIL-STORM IN TEXAS.

BY LIEUTENANT GEORGE M. BACHE, U. S. A.

One of those terrific hail-storms often heard of, but seldom experienced, visited this city last evening.* Captain A., Doctor B., and myself were returning from a day's fishing some ten miles from San Antonio, in an army ambulance, about 7 p. m., when we first noticed indications of rain. Dark clouds were rising in the northwest, accompanied with a great deal of what we at first supposed to be heat lightning. This gradually became more vivid, the clouds blacker, the thunder began to make itself heard, and our first supposition of a light shower changed to a certain prospect of a severe storm.

The mules were put to their most rapid gait, with the hope of reaching town before the tempest assailed us, but to no purpose; it broke on us when we were about two miles from home. A fierce wind from about due north, driving sheets of rain right in our faces, put a stop to any further progress, and compelled us to turn the ambulance from the direction of the storm into the "mesquite" bushes, where we prepared ourselves to quietly sit and take the result. Suddenly, however, something struck the side of the ambulance, with a noise similar to that of a stone violently thrown—another, and another—and now we hear the resounding thuds on the bodies of the mules, and the war of the elements has commenced in earnest. Neither mule nor man was prepared for this, and the former, beaten to infuriation, dashed off wildly into the mesquite bushes. It was impossible to see, and, fearing a capsize and a drag in the chaparral, we jumped out, still not realizing what was upon us; for all this had happened in a few moments of time.

Continuous blows on the head, body, and legs soon enabled us to realize the serious nature of our condition. Stones of ice of all shapes and of the size of the fist, cut and bruised our bodies, and with our arms crossed above our heads we rushed to secure the slight protection of a mesquite bush, there being no trees on the prairie. We were each at different times knocked down by blows about the head; one of us, Captain A., three times. Cut, bleeding, bruised, and still with no prospect of abatement, not knowing how long such a phenomenon might last, nor how soon we might be rendered senseless, we felt our situation as by no means enviable.

In the mean time, the mules, which having again headed the storm in their fury were nearly stunned by repeated blows on the head and sides,

* May 10, 1868.

came near us, being driven before the storm, but too much weakened to move rapidly. We took advantage of this and leaped into the ambulance, choosing the lesser evil. Providentially the wheels of the carriage became locked in a rail fence, and the mules were too much exhausted to do any more running. We put the seats over our heads, and thus protected, drenched, shivering with cold, and continually beaten on the legs and sides, we awaited the subsidence of the storm. The falling of the hail lasted twenty-two minutes, commencing at half past eight p. m. It was accompanied with heavy rain, bright blinding flashes of lightning, and a continuous roar, varied with sharp crashes, of thunder. The rain ceased with the hail, but fell very heavily again during the night, causing a rise of nearly twenty feet in the San Antonio river. The curtains of our ambulance were cut to ribbons, and we scarcely thought the mules would live through the tempest, but they did, and, though much bruised and stunned, brought us safely to town. With black eyes, bloody heads, smashed hats, bruised arms, and torn and muddy clothes, we appeared as if we had just come from a free fight and had been very badly used. Indeed, experience only could have convinced us that any one could have endured exposure to such a violent storm and lived.

We found our house flooded with water, and all the window panes and venetian blinds on its north side smashed to pieces. Persons who were in the house describe the noise of the hail as it struck the roof and sides as exceedingly terrific. The next morning the town presented the appearance of a bombarded city. The houses appeared as if thousands of shots had been fired against their walls and roofs at point-blank range. The walls of our house, covered with an inch thickness of plaster on the outside, show, as in the inclosed photograph, the innumerable dents made by the hail. Shingle roofs were broken by the hail and scattered in pieces by the wind. Large holes were cut through tin roofs and gutters. Several houses were entirely unroofed; among others, that of General Mason, who, with his family, took refuge in a doorway. The walls of an old church were blown down and its roof deposited in the street. Trees, in some instances, were torn up by the roots, and in others thrown down. In one case a hail-stone penetrated the roof of a house and did not spend its force until it reached the floor. The trees and bushes were entirely stripped of their foliage, and small branches cut off. The Indian corn was cut down as if with a scythe, and vegetables and flowers beaten into the ground. The largest authenticated stone that I have heard of weighed two pounds, though there are various reports of five and six-pounders. The stones probably averaged from four to eight ounces, and were of the size of the fist and upwards. The very large ones, of two pounds and thereabouts, must have been few and far between, as nothing could have withstood them. They were irregular in shape, as if, in their descent, many had been frozen together and thus formed one mass as hard as rock.

A woman who, with her husband, had camped out on the prairie, had two ribs broken, and was thought to be fatally injured. A dog was killed outright; and there are numerous cases of cuts and bruises, more or less severe. There are also reports of fatal casualties to human life in the vicinity, which have not yet been authenticated. The momentum of the hail-stones is shown by the fact, as witnessed by myself, of a hole about four inches in diameter through both sides of a sheet-iron stove-pipe which rose from the roof of a small out-house in the garden and did service as a chimney. Boards of fences were knocked off and split in pieces, and trees barked as if by cannon balls. I think the storm of hail not to have extended over a path of more than two miles in width. We hear of the storm having visited other places, but having no communication, save by stages and a semi-weekly paper, we have not yet learned its course. The hail came down at an angle of about 30° from the horizontal, and lowered the temperature from 90° to 64° Fahrenheit. The day had been close and sultry. The temperature again rose after the storm, and the stones on the ground were soon melted.

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